UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southwest Region
501 West Ocean Boulevard, Suite 4200
Long Beach, California 90802-4213

JUL 3 2002

IN RESPONSE REFER TO:
SWR-99-SA-104:SW

James N. Seiber, Director
United States Department of Agriculture
Pacific West Area, Western Regional Research Center
Agricultural Research Service
800 Buchanan Street
Albany, California 94710-1105

Dear Director Seiber:

Enclosed is the National Marine Fisheries Service's (NOAA Fisheries) biological opinion concerning the effects of the proposed five year *Egeria densa* Control Program in the Delta on the endangered Sacramento River winter-run chinook salmon (*Oncorhynchus tshawytscha*), threatened Central Valley steelhead (*O. mykiss*) and threatened Central Valley spring-run chinook salmon (*O. tshawtscha*), and critical habitat for the Sacramento River winter-run chinook salmon, Central Valley steelhead and Central Valley spring-run chinook salmon (Enclosure 1).

NOAA Fisheries concludes that the U.S. Department of Agriculture-Agriculture Research Service (USDA-ARS) and State of California Department of Boating and Waterways' *Egeria densa* Control Program is not likely to jeopardize the continued existence of the winter-run chinook salmon, steelhead, or spring-run chinook salmon, nor result in the destruction or adverse modification of winter-run chinook salmon critical habitat, spring-run chinook salmon critical habitat or steelhead critical habitat. Because NOAA Fisheries anticipates some incidental take of winter-run chinook salmon, steelhead, and spring-run chinook salmon as a result of project operations, an incidental take statement is also attached to the biological opinion. This take statement includes several reasonable and prudent measures that NOAA Fisheries believes are necessary and appropriate to reduce, minimize, and monitor project impacts. Terms and conditions to implement the reasonable and prudent measures are presented in the take statement and must be adhered to in order for take incidental to this project to be exempt from the prohibitions of section 9 of the Endangered Species Act.

The biological opinion also provides several conservation recommendations for winter-run chinook salmon, spring-run chinook salmon, and steelhead trout that include the use of adaptive management procedures that will decrease the risk of detrimental impacts on listed salmonids, and studies designed to explore alternative control measures for *Egeria densa* to (1) reduce risks to juvenile salmonid rearing and adult/juvenile migration and in the Sacramento-San Joaquin

Delta; (2) reduce dependence upon chemical controls in the Delta, and (3) focus on a long-term goal of eradication of *Egeria densa* within the Sacramento-San Joaquin Delta.

This document also transmits NOAA Fisheries' essential fish habitat (EFH) Conservation Recommendations for chinook salmon (*Oncorhynchus tshawtscha*) as required by the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) as amended (16 U.S.C. 1801 et seq.; Enclosure 2).

The USDA-ARS has a statutory requirement under section 305(b)(4)(B) of the MSFCMA to submit a detailed response in writing to NOAA Fisheries that includes a description of measures proposed for avoiding, mitigating, or offsetting the impact of the activity on EFH, as required by section 305(b)(4)(B) of the MSFCMA and 50 CFR 600.920(j) within 30 days. If unable to complete a final response within 30 days of final approval, USDA-ARS should provide NOAA Fisheries an interim written response within 30 days, with a final, detailed follow-up response.

We appreciate your continued cooperation in the conservation of listed species and their habitat, and look forward to working with you and your staff in the future. If you have any questions regarding this consultation, please contact Ms. Shirley Witalis in our Sacramento Area Office, 650 Capitol Mall, Suite 8-300, Sacramento, CA 95814. Ms. Witalis may be reached by telephone at (916) 930-3606 or by FAX at (916) 930-3629.

Sincerely,

James H Lecky
for Rodney R. McInnis
Acting Regional Administrator

Enclosures (4)

cc: Jim Lecky, NOAA Fisheries, PRD, Long Beach, CA
Stephen A. Meyer, ASAC, NOAA Fisheries, Sacramento, CA
Lars Anderson,USDA-ARS Weed Science Program
Patrick Thalken, DBW
Justin Ly,USFWS
Rudy J. Schnagl, California Regional Water Quality Control Board
Bill Jennings, Deltakeepers

Endangered Species Act -Section 7 Consultation

BIOLOGICAL OPINION

Agency: U.S. Department of Agriculture, Agricultural Research Service, Pacific West Area, Western Regional Research Center

Activity: *Egeria densa* Control Program for 2002

Consultation Conducted By: Southwest Region, National Marine Fisheries Service

Date Issued: JUL 3 2002

I. INTRODUCTION

This document represents the National Marine Fisheries Service (NMFS) biological opinion (Opinion) based on our review of information provided by the U.S. Department of Agriculture, Agricultural Research Service (USDA-ARS) and the State of California Department of Boating and Waterways (DBW) Weed Control Unit, for the implementation of the proposed *Egeria densa* Control Program (EDCP) at several sites in the Sacramento/San Joaquin Delta and its tributaries, in accordance with section 7 of the Endangered Species Act (ESA) of 1973, as amended (6 U.S.C. 1531 et sq.).

This Opinion relies, in part, on the following documents: *Egeria densa Control Program Volume I: A Draft Environmental Impact Report, March, 2000; Egeria densa Control Program Volume II: Research Trial Reports, March 2000; Egeria densa Control Program Volume III: Response to Comments and EIR Errata, February, 2001;* the *Biological Assessment for the Egeria densa Control Program and Two-Year Komeen Research Trials, May 15, 2000*; and the *Egeria densa Control Program Annual Report for 2001 Application Season.*

Consultation History

On April 17, 2000, NMFS received a public notice of availability of a Draft Environmental Impact Report (Draft EIR) for the *Egeria densa* Control Program.

On April 20, 2000, NMFS biologist Shirley Witalis attended a public meeting at DBW's Sacramento office to hear a description of the *Egeria densa* control methods, and was provided with a copy of the Draft EIR. NMFS' Sacramento and Santa Rosa offices prepared comments on the proposed control program, and submitted letters to DBW on May 26, 2000.

A draft Environmental Impact Report (EIR) for the proposed *Egeria densa* Control Program (EDCP) was prepared by the State of California Department of Boating and Waterways (DBW) and submitted to NMFS in March 2000. A Biological Assessment (BA) for the EDCP and Two-Year Komeen® Research Trials, dated May 15, 2000, was received by NMFS on May 17, 2000. Consultation for the control program was initiated by correspondence dated May 25, 2000, from USDA-ARS, and received by NMFS on May 26, 2000.

A multi-agency meeting convened on September 7, 2000 to discuss the *Egeria densa* control program in depth, and address the concerns of the U.S. Fish and Wildlife Service (USFWS) and NMFS regarding EDCP's potential impacts to listed species in the Delta. The meeting discussion centered on developing an operations matrix of measures to reduce potential impacts to listed species during *Egeria densa* control treatments and operations.

Consultation on the EDCP continued through additional agency meetings on September 28th, November 14th and December 14th, 2000. Various participants included: Lars Anderson of USDA-ARS; Don Waltz, Patrick Thalken, Tim Artz, and Marcia Carlock of DBW; Eliza Sater of the Department of Water Resources (DWR); Joel Trumbo of California Department of Fish and Game (DFG); Jim Gibson and Erik Nylund of the New Point Group, Consultants; Paul Hanna, Kim Webb and Terry Adelsbach of the USFWS; and Shirley Witalis and Chris Tatara of NMFS. Various written, electronic and oral communications concerning points of discussion and clarification on issues occurred throughout this period between DBW and NMFS.

Additional information to the EDCP consultation included the tentative National Pollution Discharge Elimination System (NPDES) Permit for the EDCP, dated March 12, 2001, and received by NMFS on March 16, 2001; and an official copy of the adopted California Regional Water Quality Control Board *Order No.5-01-106*, dated May 25, 2001, and received by NMFS on May 30, 2001.

On July 23, 2001, NMFS sent a letter to USDA-ARS's request of July 7, 2001 to initiate the EDCP for the 2001 application season, if allowed to follow ESA-sanctioned protocols established for the Water Hyacinth Control Program (WHCP). A total of 801 gallons of Reward® and 7,050 pounds of Sonar® were applied to 348 acres during the 2001 EDCP treatment season.

On September 25, 2001, NMFS received a letter from USDA, dated September 20, 2001, for re-initiation of consultation on the EDCP for the following 2002 application season.

On December 31, 2001, NMFS received the Annual Report for the Department of Boating and Waterway's EDCP, 2000/01, prepared by the DBW staff of the Aquatic Week Unit.

On January 18, 2002, a meeting was held among representatives of USDA-ARS, DBW, and NMFS, to review of first season of the *Egeria densa* program, and the status of the *Egeria densa* biological opinion.

On February 27, 2002, a memorandum from the California Department of Pesticide Regulation (DPR) was forwarded from DBW to NMFS, concerning DPR's labeling guidelines for herbicides including Reward®, weed control chemical in the EDCP.

On May 15, 2002, NMFS received a facsimile of the State Water Resources Control Board letter, dated April 23, 2002, acknowledging receipt of a Notice of Intent from DBW to comply with the terms of the statewide General Permit *No.CAG990003*.

On June 27, 2002, NMFS received a Notice of Intent from DBW dated June 26, 2002, to begin the EDCP with Sonar® chemical treatment at five high priority sites within the project area.

The Opinion's terms and recommendations herein are based upon completed analysis of the EDCP, and supercedes the conditions for implementation of the 2001 EDCP application season as stated in NMFS' July 23, 2001 letter to USDA-ARS. A complete administrative of this consultation is on file at NMFS' Sacramento Field Office.

II. Description of the Proposed Action

The DBW requested the USDA-ARS to act as the federal nexus partner to implement the EDCP and initiate formal consultation with the NMFS pursuant to section 7 of the ESA. The USDA-ARS, in fulfillment of their directive to control and eradicate agricultural pests, has contracted with the DBW to conduct research activities in association with the EDCP and to provide guidance during implementation.

The *Egeria densa* Task Force, led by USDA, proposes to conduct a five-year program aimed at chemically controlling the growth and spread of *Egeria densa* with the aquatic herbicides Reward® and Sonar®, and a two-year study to research the aquatic herbicide Komeen® for its possible future employment in the EDCP. Should the DBW determine at any point during the five-year period that the EDCP is ineffective, the DBW would recommend to the legislature and appropriate regulatory agencies that EDCP activities cease. However, if the EDCP is effective, the DBW would submit supplemental environmental documentation that supports continuation of the EDCP (DBW 2000).

Egeria densa Control Program

The purpose of the EDCP is to control the growth and spread of *Egeria densa* (*Egeria*) in Delta waterways. Three state-registered control methods are proposed for EDCP treatment sites: (1) contact herbicide Reward® (active ingredient Diquat); (2) systemic herbicide Sonar® (active ingredient fluridone) in liquid aqueous solution (A.S.), solid pellet form (SRP), and precision-release pellet (SR) forms; and (3) mechanical harvesting. Reward® would be applied in fast moving waters (76 percent of treatment acreage); Sonar® would be applied in slow-moving, quiescent waters (21 percent of treatment acreage), and mechanical harvesting would be used to gain immediate control of 3 percent of the treatment acreage. Based on the proposed 5-year treatment period, the DBW would apply 10,600 gallons of Reward®, 300 gallons of Sonar®A.S., and 13,500 pounds of Sonar®SRP to Delta waters annually. Sonar®PR, recently incorporated in the control regime, may be applied at some time during the 5-year EDCP. The EDCP would treat 1,583 acres in years 1-2, increasing treatment to 1,733 acres in years 3-5. All proposed treatment sites occur in the Delta; there is currently no evidence of *Egeria* found within Suisun Marsh. Specific details of the EDCP can be found in the *Egeria densa Control Program Volume 1: Draft Environmental Impact Report* (DBW 2000a).

EDCP Action Area

Thirty-five (35) sites have been prioritized as potential EDCP treatment sites within the Delta. The Delta is defined as being bordered to the north by the I Street Bridge in Sacramento, to the west by the Suisun Marsh Salinity Control Gates near Pittsburg, to the south by the junction of Highways 5 and 205, and to the east by the Port of Stockton, covering overlapping jurisdiction of six counties. The sites chosen for the EDCP are scattered throughout the Delta, but are prioritized on the basis of channel navigation (*see* Enclosure 2).

Komeen® Research Trials

Komeen® is a non-selective liquid contact herbicide that contains eight-percent elemental copper. The herbicide acts by inhibiting photosysthesis after being absorbed into plant tissue. DBW has determined that Komeen® would be more effective in controlling *Egeria* in high flow conditions in comparison to other EDCP herbicide controls. The goals of the Komeen® Research Trials are to determine the long-term fate of copper applied to Delta waters, and whether copper compounds in Komeen® could ionize to more toxic forms of copper. There will also be additional laboratory toxicity tests conducted to assess Komeen toxicity to some fish and invertebrate species. The proposed research trials would involve Komeen® application at three 50-acre sites in the Delta twice each year for two years, resulting in treatment of 300 acres per year, or 600 treatment acres over the two-year period. Applications would be made to achieve a water column concentration of 0.75 parts per million (ppm) copper, for a total amount of 6,075 gallons per year, or 12,150 gallons of Komeen® over the two-year trial period. Komeen® would be applied using weighted hoses dragged below the water surface. Approximately 6,075 gallons of Komeen® would be applied to the Delta annually. The three primary components of the Two-Year Komeen® Research Trials are: (1) monitoring of sediment copper concentration, (2) assessment of Komeen® /copper bioaccumulation in target and non-target organisms, and (3) laboratory toxicity studies. It is currently unknown if Komeen application produces measurable increases in downstream sediment copper load or whether the copper compound in Komeen® could ionize to more toxic forms of copper. If at the end of the 2-year study, it is concluded by the USDA-ARS that Komeen® use is consistent with EDCP objectives and does not result in significant environmental impacts, the DBW would take steps to incorporate Komeen® into the EDCP. USDA-ARS would be required to re-initiate ESA consultation for project analysis incorporating Komeen® as an herbicide in controlling *Egeria.*

Komeen® Action Area

The action area for the Komeen trials lies within the EDCP project area. Three sites have been proposed for implementation of the Komeen trials during the 2-year study. The first two sites, Sherman Island and Big Break Island, are high flow sites with partial and large tidal exchanges, respectively; the third trial site, Disappointment Slough, is an area with high water flow and large tidal exchange (DBW 2000).

Natural History of Egeria densa

Egeria, family Hydrocharitaceae, is a non-native submerged, aquatic macrophyte that grows in dense mats throughout approximately 3,900 surface acres, or eight percent of the 50,000 surface acres of the Delta. *Egeria* is commonly used as decorative vegetation in aquaria, and has been introduced world-wide from its native South East Brazil. In natural waters, it can grow at 1-3 meters depth within a wide range of lentic and lotic systems.

Growth rates depend largely on the amount of light and nutrients available. The biological requirements of *Egeria* include medium to very high light exposure, water temperatures between 10-26°C, water hardness ranging from soft to very hard, and a pH range of 5 to10. *Egeria* has a very high nutrient absorption rate.

Egeria will grow at less than optimum conditions, resulting in a lighter and thinner appearance. The small leaves are strap-shaped, about one inch long and 1/4 inch wide, in whorls of three to six around the stem. The white petal flowers are on short stalks about one inch above the water. Dense canopies of *Egeria* can block light from other plants living in the same area, and also decrease dissolved oxygen (DO) levels during both the day and night. *Egeria* secretes antibiotic substances which inhibit blue-green algae (*Cyanobacteria*) growth. The plant is able to reproduce sexually and asexually, with fragmentation as the primary mechanism of reproduction. Cyclic periods of drought, such as those experienced in the Central Valley of California, encourage growth acceleration in *Egeria*. *Egeria* exhibits a lack of tolerance to saline water or brackish conditions.

Control Methods

Reward®

Reward® (36.4 percent active ingredient diquat dibromide) is a non-selective herbicide requiring direct contact with plant tissue to effectively kill the plant's membranes. Reward® is the expected method of control in 78 percent of the applications over the 5-year application program. Twenty-two plots have been proposed for exclusive treatment with diquat and an additional seven plots will be treated with diquat and in conjunction with another treatment method. Diquat is fast-acting and quickly absorbed through the plant cuticle, passing into the cytosol of the plant. It then forms superoxide free radicals that are converted into hydrogen peroxides by the enzyme superoxide dismutase. The hydrogen peroxide and superoxide anion can attack polyunsaturated lipids present in the cellular membranes to produce lipid hydroperoxides which, in turn, can react with unsaturated lipids to form more lipid free radicals (Klaassen 1996).

Diquat easily binds with organic particles and its effectiveness is diminished to a degree in turbid and muddy waters (Murphy and Shelton 1996). Diquat dibromide's half-life is less than 48 hours in the water column, and may be on the order of 160 to 1000 days in sediments due to its low bioavailability (Tucker 1980 and Gillett 1970; Wauchope 1992). Because it quickly binds to particles and becomes biologically unavailable, its persistence in waters is assumed to be limited. At 22 days after a weed-infested artificial lake was treated, only 1 percent of the applied diquat dibromide remained in the water and 19 percent was adsorbed to sediments (Howard 1991).

Although water soluble (Wauchope 1992), diquat's capacity for strong adsorption to soil particles suggest that it will not easily leach through the soil, be taken up by plants or soil microbes, or broken down by sunlight (photochemical degradation). Field and laboratory tests show that diquat usually remains in the top inch of soil for long periods of time after it is applied (Tucker 1980). Trophic status as well as nutrient levels influence diquat's disappearance rate (Pratt *et al.*1998). For example, cyanobacteria are very sensitive to diquat, exhibiting persistent but varying response effects to the chemical in laboratory trials within low, medium and high nutrient microcosms.

Sonar®

Sonar® is a systemic herbicide that is absorbed by plant shoots as well as the roots of aquatic vascular plants. There are two formulations for Sonar®: Sonar®A.S. (aqueous liquid), to be applied below the water surface, and Sonar®SRP (solid pellet), a controlled release form that is broadcast over a treatment area. Sonar® PR, a variant of Sonar®SRP, is a precision release pellet. Sonar® A.S. (41.7 percent active ingredient fluridone) is the expected method of control in 11 percent of the applications, and Sonar®SRP (5.0 percent active ingredient fluridone) is the expected method of control in 8 percent of the applications, over the 5-year EDCP program. Sonar® PR may be adopted into the EDCP application regime in the future.

Fluridone inhibits the formation of carotenoids, which enhances the degradation of chlorophyll, thereby limiting photosynthesis (conversion of carbon dioxide and water into carbohydrates utilizing light energy to drive the reaction). Sonar® is most effective when applied during the early growth stages; its' effect varies with season, stage of plant growth, and water movement. Fluridone is not effective as a spot treatment (Murphy and Shelton 1996).

Retention time changes seasonally, influenced by photoperiods. Longer retention occurs when photoperiods are short and/or indirect (during fall and winter). Sediment retention of fluridone may be from four months to one year (CRWQCB 2001).

Mechanical Control

The DBW proposes to use mechanical harvesting on an estimated 3 percent of the treatment sites to create navigable channels by which their boat may enter an area to apply chemical control. Harvesting removes surfacing mats of *Egeria* and creates open areas of water. The above-ground portion of *Egeria* would be cut and removed, then transported from the harvester by a conveyer belt secured onto the levee. The cuttings would be collected by disposal vehicles positioned under the conveyer belt, and moved to a disposal site. The *Egeria* would be allowed to dry for 30 days, and eventually be disked into the soil. *Egeria* does not appear to accumulate metals and chemicals at a toxic or harmful level, and therefore would not contaminate disposal sites.

As *Egeria* spreads readily through fragmentation, mechanical controls such as cutting, harvesting, and rotovation (underwater rototilling) can be used only when the extent of the infestation is such that all available niches have been filled. The use of mechanical controls during plant invasion could enhance the rate of spread, as *Egeria* fragments left within the water column can regenerate; therefore, DBW will only employ mechanical harvesting as deemed necessary.

There is some chance that salmonids could be impacted by mechanical harvesting if they are trapped under an *Egeria* mat when harvesting takes place. However, the probability is low, as DO concentrations under *Egeria* matting would not be favorable to salmonids (falling below the viable salmonid DO range 6 - 11 ppm).

EDCP Adaptive Management

DBW's proposed operation and maintenance will allow the DBW to re-evaluate the project protocol as new data and information becomes available, to enhance the efficiency of the program and minimize impacts to salmonids and critical habitat. The proposed adaptive management strategies include:

- evaluating the need for weed control measures on a site-by-site basis;
- selecting appropriate indicators for pre-treatment environmental monitoring;
- monitoring indicators following treatment and evaluating data to determine program efficacy and environmental impacts;
- supporting ongoing research to explore the impacts of the EDCP and alternative control methodologies;
- reporting findings from monitoring evaluations and research to regulatory agencies and stakeholders;
- adjusting program actions, as necessary, in response to recommendations and evaluations by regulatory agencies and stakeholders.

In addition, the EDCP Task Force will meet annually to discuss the status of the EDCP and control specifics for upcoming *Egeria* treatment seasons.

EDCP Protocol

The EDCP proposed treatment season extends from March through November. Five crews, each consisting of a Specialist and a Technician, would carry out the control program. A Field Supervisor would manage daily operations, and assign spray locations to the crews on a weekly basis. Approximately 35 treatment sites have been identified for the first treatment season, and would be prioritized according to impacts to navigation and the extent of obstruction. Treatment locations would be determined by weather and tidal conditions, the presence of agricultural crops, native vegetation, potable water intakes, and wildlife. Reward® and Sonar®A.S. will be applied from 19- to 21- foot airboats by subsurface applications through weighted hoses dragged below the water surface. Reward® may be applied up to two times per year at a given site and Sonar®A.S. will be applied over a six to eight week period with the total concentration of applied herbicide not exceeding 150 parts per billion (ppb). Sonar® SRP will be broadcast over the treatment area from an airboat using hand-held spray nozzles. The total concentration of applied Sonar® SRP will not exceed 150 ppb. Waste products, including both active and inert chemical ingredients and dead plants, would be left to sink into the substrate or be carried downstream by water flow. DBW operations are expected to result in DO level changes to no less than 5.0 milligrams per liter (mg/L) in open fast-flowing waters. DBW operations are expected to operate at DO level conditions of 3.0 mg/L in closed, shallow, and/or slow-gradient waters. Temperatures are expected to increase by no more than 4^0F in the receiving waters due to the project's implementation (or 2^0F, depending on ambient water temperatures). No control chemical will be discharged under high wind, high water flow or wave action because these actions disperse chemicals and could indirectly target listed salmonids during herbicide application.

Reward® Landscape and Aquatic Herbicide applications for the control of *Egeria* may be applied at 14-day intervals, as needed, to ensure control of missed plants and regrowth; 1/3 to 1/2 of the water body area may be treated at one time. Number of applications are limited to 4 per treated area per year.

Sonar®A.S., Sonar® SRP, and Sonar® PR are to be applied to slow-moving bodies of water in a pattern that provides uniform distribution and avoids concentration of the herbicide.

The DBW is obliged to follow the DPR procedures for pesticide application, and to obtain a Restricted Use Permit from the County Agricultural Commissioner of each county where they will be treating.

EDCP Monitoring Program

As a requirement of the NPDES permit, the DBW will follow monitoring protocol terms imposed by the Board.

The DBW has implemented pre-treatment and post-treatment monitoring for biological, chemical, and physical indicators associated with each *Egeria* control. The objectives of monitoring are: (1) determine if environmental conditions are conducive to chemical or mechanical treatment; (2) collect data for environmental baseline conditions, for assessment of environmental impacts and treatment efficacy, and (3) determine if treatment protocols need to be modified to reduce environmental impacts.

Pre-treatment monitoring involves taking measurements of physical and chemical parameters, including water temperature, water flow rate, turbidity, DO, pH, and concentrations of aquatic herbicides prior to treatment. Post-treatment monitoring consists of taking measurements of DO, pH, and aquatic herbicides concentrations. *Egeria* biomass and fragments are quantified before and after treatment to determination overall efficacy of the EDCP and possible modifications to the treatment protocol. Specific mitigation measures for the *Egeria* control program are proposed by the DBW to avoid or minimize potential impacts where available. Consultation with various state and federal agencies regarding impacts and mitigation measures for future revisions or additions to the mitigation measures will be on-going.

Komeen® Monitoring Program

The proposed monitoring program for Komeen® Trials is similar to that of the EDCP, with the addition of sampling for total and dissolved copper concentration prior to and following all Komeen® applications. Six water samples will be collected at 0, 3, 6, 12, 24, and 48 hours following treatment, and analyzed for herbicide dissipation. Prior to Komeen® treatment, several traps containing native fishes will be placed at varying depths throughout the treatment areas to determine the effects of short-term exposure to Komeen®. The fish will be held in the traps for 96 hours after treatment to deter any mortality due to short-term exposure. Sediment will be sampled from the area before and after Komeen® treatment to track the fate of the elemental copper in Komeen® .

Adjuvants

In addition to the chemical controls above, adjuvants would be used in conjunction with chemical treatments. Adjuvants reduce chemical drift and spray of non-target areas and increase adhesion of the herbicide to treated vegetation. They are: (1) Placement®, a deposition and retention agent that reduces evaporation and drift of chemicals while increasing coverage and adherence in the target area; (2) R-11® Spreader-Activator, a combined spreading-activating compound for increasing the efficiency of action for agricultural chemicals where quick wetting and uniform coverage is required; and (3) Agri-Dex® Nonionic, used to improve pesticide application by modifying the wetting and deposition characteristics of the application solution. Carcinogenic or aquatic environmental risks are minimal, if label recommendations are followed.

Placement® is composed of amine salts of organic acids, aromatic acids, and aromatic and aliphatic petroleum distillates. Placement® is used as a surfactant with all three herbicides at a rate of one part surfactant to four parts herbicide mixed into the total aqueous volume. The manufacturer's Material Safety Data Sheet (MSDS) for Placement® (Wilber-Ellis) recommends that no more than one quart of the surfactant be applied per surface acre of water.

R-11® Spreader-Activator (Wilbur-Ellis) is composed of alkyl aryl polyethoxylates, compounded silicone and linear alcohol. It is used with all three herbicides at the rate of two quarts per 100 gallons of spray solution.

Agri-Dex® is a non-ionic blend of surfactants and spray oil (Helena). It is composed of a paraffin based petroleum oil and polyoxyethylate polyol fatty acid esters. Agri-Dex® will be used with all three herbicides at a rate of one to four pints per 100 gallons of spray solution, not to exceed 2.5 percent v/v concentration.

Environmental Monitoring

The monitoring program includes a daily log with site specifics (e.g. location, wind, chemicals used, rate of chemical application, and current wind speed), DO levels, pH, and pre-treatment and post-treatment levels of chemical residues. DBW will consult the Interagency Ecological Program (IEP) Real-Time Monitoring website for reported incidence of salmonids within the intended treatment area on a weekly basis, and prior to chemical application, to minimize possible chemical impacts on salmon and steelhead. Three times each year, monitoring will be initiated at two sites in each of the four water categories (tidal, slow-moving, fast-flowing, dead-end slough) for the chemicals applied, DO and toxicity. Each chemical used in the EDCP will be subject to water quality and toxicity monitoring at least once each year.

Pre-Treatment

One hour prior to treatment, a reading of the ambient DO, temperature and turbidity will be taken in the treatment area at the midpoint of the water column or at a depth of 5 feet, whichever is closer to the surface. An ambient chemical residue sample will also be taken in the treatment area at the midpoint of the water column or at a depth of 5 feet, whichever is closer to the surface, at the same location.

Post-Treatment

Upon completion of the chemical application, DBW will take ambient DO, temperature and turbidity readings at mid-point in the water column or at a depth of 5 feet; whichever is closer to the surface. Temperature, DO and turbidity readings will continue until dead plants are no longer observable and the readings within and 100 yards downflow of the treatment area are within 0.5 mg/L of the readings 100 yards upflow of the treatment area. Actual distances downflow and upflow will vary based on site characteristics and will be established using best professional judgment.

Chemical residue and toxicity samples:

- diquat - within two hours post-treatment, the DBW will take one water sample for chemical residue and one water sample for toxicity. These samples will be taken within the application site at the mid-point in the water column or st a depth of 5 feet, whichever is closer to the surface.

- fluridone - within one week after the final application, the DBW will take a chemical residue sample within the application site at the mid-point in the water column or at a depth of 5 feet; whichever is closer to the surface. The DBW will continue weekly taking residue samples at this same location until fluridone concentrations are no longer detectable.

The time, latitude and longitude of the sampling location for each set of samples will be recorded for later incorporation into a GIS database.

The DBW has Memorandum of Understandings (MOU) with water agencies outlining application restrictions. Prior to any future work within one mile of drinking water intakes, the DBW will develop a protocol for sampling post-treatment chemical residue around the intakes.

Other monitoring protocols being carried out by DBW and relevant to listed salmonid species includes observation of dead fish and native vegetation; visual assessment of water quality and photo documentation of fish and native vegetation pre- and post- chemical control applications; and tracking of planktonic, microbial and macro-invertebrates.

The EDCP technical crew is trained in fish species identification, and recognition of fish habitat in the Delta and associated waterways, by the DBW environmental scientist.

Waste Discharge Requirements

A tentative NPDES Permit No. CA0084735, dated March 12, 2001, provides the waste discharge requirements for the EDCP, as mandated by the California Regional Water Quality Control Board (Board), Central Valley Region. The NPDES permit lists a number of procedures that the EDCP is required to follow in order to maximize efficacy of control efforts and minimize adverse impacts to the environment. The NPDES permit does not address the copper-based herbicide, Komeen®. Among the conditions required by the Board's Order are the following requirements having specific relevance to Federally-listed salmonid species and their designated critical habitat:

- The periodic use of rhodamine dye will help judge the rate of water movement and chemical dispersion.

- Discharges must be consistent with both State and Federal anti-degradation policies.

- Compliance is required with procedures designed to minimize the area impacted by the project and monitoring to evaluate the extent of the impacts on the narrative and numeric objectives addressed within waste discharge requirement #31 of the NMDES permit (bacteria, biostimulatory substances, chemical constituents, color, dissolved oxygen, floating material, oil and grease, pH, pesticides, radioactivity, salinity, sediment, settleable material, suspended material, tastes and orders, temperature, toxicity and turbidity).

- The concentration of constituents in the discharge cannot exceed the water quality objectives for the receiving water, except where a Total Maximum Daily Load (TMDL) has been established.

- Protocols are to be developed to ensure that EDCP operations do not inhibit passage of fish.

- Sediments are to be sampled for the chemicals used by the program to determine whether they build up to harmful levels in sediments under the conditions found at treatment sites.

III. STATUS OF THE SPECIES AND CRITICAL HABITAT

The Delta includes designated critical habitat for endangered Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), threatened Central Valley spring-run Chinook salmon (*O. tshawytscha*) and threatened Central Valley steelhead (O. *mykiss*). It is a major adult and juvenile migration corridor for all runs of Central Valley Chinook salmon and steelhead utilizing the Delta. Juvenile salmon often enter the Delta before they are physiologically able to enter salt water, and rear there several months before migrating to the ocean. The proposed March through November implementation of *Egeria* control measures would occur during the upstream migration of adult winter-run and spring-run Chinook, and steelhead; and during the emigration of juvenile winter-run and spring-run juvenile Chinook, and juvenile steelhead. Virtually all runs of Chinook salmon and steelhead utilizing the Delta could be directly or indirectly impacted by the EDCP.

Sacramento River Winter-run Chinook Salmon ESU and Critical Habitat

Listing history Overview

The Sacramento River winter-run Chinook salmon were determined by NMFS to be a unique evolutionarily significant unit (ESU), endemic to the Central Valley of California. The State of California listed winter-run Chinook salmon as endangered in 1989 under the California State Endangered Species Act (CESA). NMFS listed winter-run Chinook salmon as threatened (54 FR 10260) under emergency provisions of the ESA in August 1989 and the species was formally listed as threatened in November 1990 (55 FR 46515). On June 19, 1992, NMFS proposed that the winter-run Chinook salmon be reclassified as an endangered species pursuant to the ESA (57 FR 27416). NMFS finalized its proposed rule and re-classified the winter-run as an endangered species under the ESA on January 4, 1994 (59 FR 440). A proposed recovery plan was published in August 1997 (NMFS 1997).

On June 16, 1993 (58 FR 33212), NMFS designated critical habitat for the winter-run Chinook salmon as the Sacramento River from Keswick Dam (RM 302) to Chipps Island (RM 0) at the westward margin of the Sacramento-San Joaquin Delta; all waters from Chipps Island westward to Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and Carquinez Strait; all waters of San Pablo Bay westward of the Carquinez Bridge; and all waters of San Francisco Bay to the Golden Gate Bridge north of the San Francisco/Oakland Bay Bridge. In the areas westward from Chipps Island, including San Francisco Bay to the Golden Gate Bridge north of the San Francisco/Oakland Bay Bridge, this designation includes the estuarine water column and essential foraging habitat and food resources utilized by Sacramento River winter-run Chinook salmon as part of their juvenile emigration or adult spawning migration.

Delta Critical Habitat

Numerous factors have effects on the condition and function of critical habitat necessary for the conservation of listed salmonids, including the Sacramento River winter-run Chinook. CALFED, through its Comprehensive Monitoring, Assessment, and Research Program (CMARP) (CALFED 2000c) has described numerous areas of concern for the restoration of habitat for Chinook salmon and steelhead trout. Within the Delta, alterations in the hydrology of the river systems feeding into the estuary have led to reductions in the volume of water flowing through the system and the timing of peak flows that stimulate migratory behavior in both juvenile and adult fish. The water storage and conveyance systems that have been constructed on the major rivers and tributaries of the Central Valley have permanently altered the natural flow patterns that native fishes have evolved to cope with. The reduction in the peak flow leads to alterations in the cycling of nutrients and changes in the transport of sediment and organic matter within the estuary. Likewise, estuarine circulation patterns have been disrupted, leading to changes in the physio-chemical profiles of the estuary, such as those for temperature and dissolved oxygen. Changes in the physio-chemical parameters of the Delta's waters can lead to distinct alterations in the historical distribution of animal and plant communities, upon which the juvenile salmon depend on for their forage base and for protective cover. Alterations in the flow patterns have led to reductions in the amount of out flowing water at the western margins of the Delta. This situation has led to increasing salinity levels within the western margin of the Delta and has changed the position and extent of the productive mixing zone upon which numerous species depend during their critical larval stages. Water flow patterns have been greatly affected by the operations of the south Delta pumping facilities. The normal pattern of water circulation within the Delta has been altered from its historical pattern, to a modified regime, which now includes a strong cross delta flow to the south, where the pumps are located as well as the creation of "null zones"; areas where flows are negligible to nonexistent and the water becomes stagnant (DWR 2001). This alteration disrupts normal environmental cues caused by tides and river out flows. Changes in the flushing rate and increased residence times of Delta waters has enhanced the degradative effects of increased input of contaminants and pollutants to the water system. This contamination has strong correlations to the increase in human activity in the terrestrial regions of the Delta. Agricultural and industrial activities have been the predominant sources of these contaminants, but the increase in the region's human population has resulted in a substantial increase in the number of new housing developments and a spreading urbanization of the Delta's terrestrial component. This urbanization has the potential to change the character of the contaminant profile, making it more complex and dispersed in its sources.

The construction of levees and the resulting channelization of the intricate web of Delta waterways have degraded the complexity of the historical habitats found in the Delta. The conversion of shallow water habitats that were found along the margins of the Delta waterways into that of a riprap lined levee has radically altered the habitat that juvenile salmonids in the Delta are exposed to. Shallow water habitats are considered essential foraging habitats for juvenile salmonids, often supporting complex and productive invertebrate assemblages. The substrate that is provided by the stone riprap is unsuitable for the colonization of native estuarine invertebrate species. Likewise, the construction of levees for flood control has disconnected the rivers and Delta from their historical floodplains. Juvenile salmonids utilize flood plains for foraging and as a refuge from high flow velocities during flooding events. Dredging of the channels for navigation or irrigation diversion purposes can result in the formation of anoxic bottom waters, and increased saltwater intrusion into upstream areas.

Introductions of invasive species, both intentionally and unintentionally, have significantly impacted the survival potential of juvenile salmonids. Non-native predators such as striped bass, large mouth bass and other sunfish species, present an additional risk to the of survival of juvenile salmonids migrating through the Delta that was not historically present prior to their introduction. These introduced species are often better suited to the changes that have occurred in the Delta habitat than are the native salmonids. The presence of the Asian Clam *(Potamocorbula amurensis)* has led to alterations in the levels of phyto- and zooplankton found in water column samples taken in the Delta. This species of clam is able to efficiently filter out and feed upon significant numbers of these planktonic organisms, thus reducing the population of the potential forage base for juvenile salmonids. Likewise, introductions of invasive plant species such as the water hyacinth (*Eichhornia crassipes*) and *Egeria densa,* has diminished access of juvenile salmonids to critical habitat (P. Moyle, personal communication). *Egeria densa* forms thick "walls" along the margins of channels in the Delta. This growth prevents the juvenile salmonids from accessing their preferred shallow water habitat along the channel's edge. In addition, the thick cover of *Egeria* provides excellent habitat for ambush predators, such as sunfish and bass, which can then prey on juvenile salmonids swimming along their margins. Water hyacinth creates dense floating mats that can impede river flows and alter the aquatic environment beneath the mats. The DO beneath the mats often drop below sustainable levels for fish due to the increased amount of decaying vegetative matter produced from the overlying mat. Like *Egeria*, water hyacinth is often associated with the margins of the Delta waterways in its initial colonization, but can eventually cover the entire channel if conditions permit it. This level of infestation can produce barriers to salmonid migrations within the Delta.

Historic Habitat Alterations

There is only one unique population of winter-run Chinook salmon, the Sacramento River winter-run, within California. Prior to construction of Shasta and Keswick dams in 1945 and 1950, respectively, winter-run Chinook salmon were reported to spawn in the headwater reaches of the little Sacramento, McCloud and Lower Pit River systems. Flows of water from constant temperature springs emanating from the lava fields around Mount Shasta and Mount Lassen fed them, and provided cool, stable temperatures for successful egg incubation over the summer. Populations of winter-run Chinook may have numbered over 200,000 fish (Moyle *et al* 1989; Rectenwald 1989; Yoshiyama *et al* 1998). Construction of Shasta Dam blocked access to all of the winter-run Chinook salmon's historical spawning grounds by 1942. Preservation of a remnant winter-run population was achieved through manipulation of the dam's releases to maintain a cold water habitat below the dam as far as Tehama.

One other potential population of winter-run Chinook salmon occurred in the Calaveras River (NMFS 1997). Several dozen to several hundred adults spawned in reaches of the Calaveras River below New Hogan Dam from the early 1970s through the mid 1980s, but were extirpated by 1985, partially due to low flows in the Calaveras River, drought and agricultural diversions.

Prior to the construction of Shasta Dam, numerous smaller dams and agricultural diversions entrained juvenile winter-run Chinook and blocked passage of adults migrating upstream. Among the earliest were the agricultural diversions of the Central Canal and Irrigation Company (CCIC) which began diverting unscreened water in 1906. This irrigation system was subsequently purchased by the Glenn-Colusa Irrigation District in 1920 and enlarged. The diversion was finally screened in 1935, but was damaged in 1938 and left unrepaired until the 1970s (NMFS 1997). In 1917 the Anderson Cottonwood irrigation diversion (ACID) dam was constructed on the Sacramento River in Redding, California and operated as a seasonal diversion dam (April-August). The dam was constructed without fish ladders and thereby effectively prevented any upstream migration of adult salmon above the dam when it was in operation. In 1927 a rudimentary fish ladder was constructed that permitted a limited number of fish to ascend into the upper watershed, but still impeded the majority of adult spawners from migrating upstream. Consequently, this barrier substantially reduced population numbers. The Pit River watershed was also dammed during the 1920s with permanent structures, blocking at least 21 miles of spawning habitat, and perhaps as much as 71 miles depending on the upstream extent of adult migration. Shasta Dam construction was initiated in 1938 following the authorization of the Central Valley Project by Congress in 1937. In May of 1942, access to the upper Sacramento watershed was blocked to all salmonids, eliminating over 50 miles of spawning habitat that still remained above the dam. The operation of Shasta Dam significantly altered the functioning of the Sacramento River. Summer flows were higher and colder than historical flows while winter flows were warmer and lower than original flows. Reservoir levels significantly effected the temperature profile of releases from the dam. Low reservoir levels in dry years often resulted in increased river temperatures in the late summer as the reservoir was drawn down. This resulted in the losses of winter-run Chinook eggs incubating in the gravel downstream of the dam when water temperatures exceeded 56°F. Keswick Dam operations often resulted in ramping rates that were incompatible to the requirements for winter-run Chinook survival below the dam. Flow fluctuations in the spring disrupted spawning activities, or dewatered redds. In the fall, rapid ramping rates often stranded winter-run fry in side channels or broad gravel flats. The Red Bluff Diversion dam (RBDD), built in 1967, created another significant barrier to upstream passage for salmonids. Although equipped with fish ladders and bypass pipes, passage was still significantly impeded. This forced numerous salmon to either delay their upstream migration, or spawn downstream of the dam where water temperature was often too high to have successful incubation of the eggs. Fish that were delayed and made repeated attempts to pass the dam often had impaired spawning success due to the expenditure of energy reserves that could have been used for the production of viable eggs and upstream migration. RBDD also impinged on the success of juveniles emigrating downstream through entrainment into irrigation canals and the increased exposure to predation as they negotiated the dam (NMFS 1997).

Chemical contamination of the Sacramento River degraded water quality as early as the 1900s through agricultural discharges, mining pit effluents (acidic water, heavy metals), pesticide runoff, and fertilizer enrichment. In the delta, increased industrialization, urban development, and oil refining operations contributed pollutants to the ecosystem as early as 1890. Contamination of the ecosystem increased in proportion to the human population through the 1950s when water quality controls where first initiated. Thereafter, water quality began to improve as the controls took effect (NMFS 1997).

Environmental conditions have played a significant role in the decline of the winter-run Chinook salmon population. During the severe droughts of the late 1920s and early 1930s, the population of winter-run Chinook salmon on the Sacramento River declined precipitously. The effects of severe drought and the increased impairment of fish migration due to dam construction in the upper watershed combined to produce several years of reduced spawning success and adult escapement. This drought period was followed in the late 1930s by a cooler, wetter climatic period that was in part enhanced by the cold tailwater outflow from the recently completed Shasta Dam. Winter-run Chinook salmon populations rebounded and continued increasing until the early 1970s, when a pattern of decline was again the dominant trend. Increased upstream water temperatures, agricultural diversions, and the initiation of operations of the RBDD all acted to reduce the success of salmon spawning and recruitment in the inland waters. Ocean conditions began to decline in the mid 1970s, and subsequently a strong El Niño condition developed in 1982-1983. Persistent dry weather conditions coupled with poor ocean conditions through most of the 1980s and early 1990s decreased the winter-run populations to their current depressed levels (NMFS 1997)(see Figure 1).

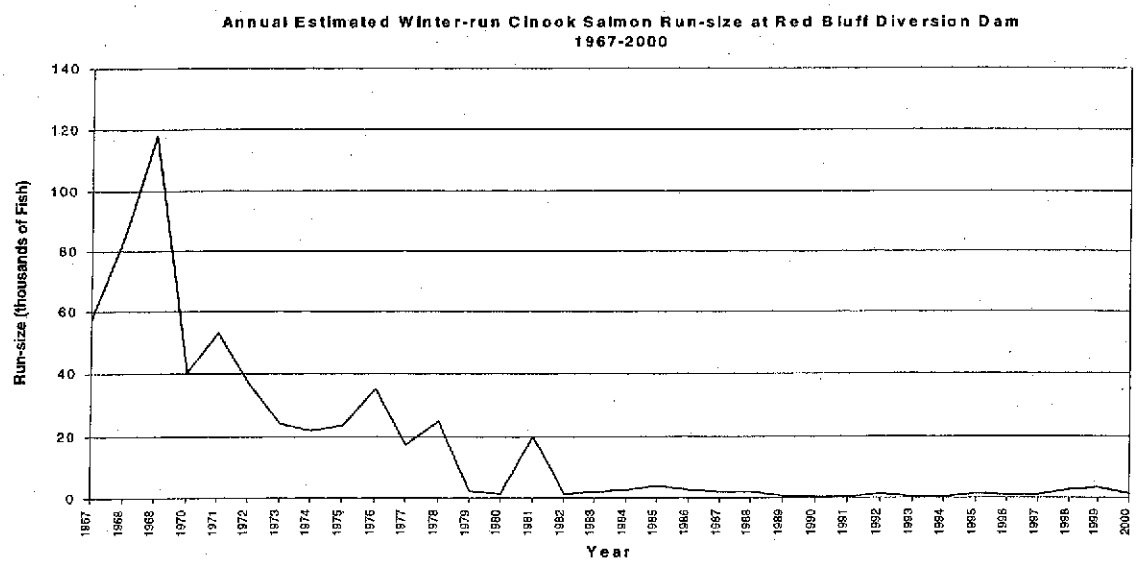
Figure 1: Sources: NMFS 1997; PFMC, Review of 2000 Ocean Fisheries

Life History Considerations

The first winter-run Chinook salmon migrants appear in the Sacramento-San Joaquin Delta during the early winter months (Skinner 1972). On the upper Sacramento River, the first upstream migrants appear during December (Vogel and Marine 1991). Due to the lack of fish passage facilities at Keswick Dam, adults tend to migrate to and hold in deep pools between Red Bluff Diversion Dam (RBDD) and Keswick before initiating spawning activities. The upstream migration of winter-run Chinook salmon typically peaks during the month of March, but may vary with river flow, water-year type, and operation of RBDD.

Winter-run Chinook salmon spawning primarily occurs between RBDD and Keswick Dam from mid-April to mid-August with peak activity occurring in May and June (Vogel and Marine 1991).

Most winter-run Chinook salmon spawners are three years old. They spawn in gravel between 1.9 cm to 10.2 cm in diameter with no more than 5 percent fine sediment composition. Winter-run Chinook salmon die after spawning. The eggs hatch after an incubation period of about 40-60 days depending on ambient water temperatures. Maximum survival of incubating eggs and pre-emergent fry occurs at water temperatures between 40°F and 56°F. Mortality of eggs and pre-emergent fry commences at 57.5°F and reaches 100 percent at 62°F (Boles *et al.*



1988). Other potential sources of mortality during the incubation period include redd dewatering, insufficient oxygenation, physical disturbance, and water-borne contaminants.

Pre-emergent fry remain in the redd and absorb the yolk stored in their yolk-sac as they grow into fry. This period of larval incubation lasts approximately 2 to 4 weeks depending on water temperatures. Emergence of the fry from the gravel begins during late June and continues through September. The fry seek out shallow nearshore areas with slow current and good cover, and begin feeding on small terrestrial and aquatic insects and aquatic crustaceans. As they grow from 50 to 75 mm in length, the juvenile salmon move out into deeper, swifter water, but continue to use available cover to minimize risk of predation and reduce energy expenditure.

The emigration of juvenile winter-run Chinook salmon from the upper Sacramento River is dependent on streamflow conditions and water-year type. Once fry have emerged, storm events may cause en masse emigration pulses. This emigration past Red Bluff may occur as early as late July or August, generally peaks in September, and can continue until mid-March or April in drier years (Vogel and Marine 1991). Data combined from trawling, seining and State and Federal water project fish salvage records in the Delta show that winter-run Chinook salmon outmigrants occur from October to early May in the Sacramento-San Joaquin Delta (DFG 1993). Emigration from the Delta might begin to occur as early as late-December and continue through June. Smolts enter the ocean at an average fork length of approximately 118 mm. The period of residency in the Sacramento River and Delta for Sacramento River winter-run Chinook salmon is between five and nine months.

Winter-run Chinook salmon are vulnerable to extinction because the species is limited to a single, isolated population without a source of immigration from subpopulations (NMFS 1997). The winter-run Chinook have a lower fecundity than most other Chinook populations and therefore have a lower reproductive potential average of 3,353 eggs per female, vs. Central Valley fall-run Chinook at 5,498 eggs per female, Columbia River Chinook salmon at 5,032-5,453 eggs per female, and Alaskan Chinook populations averaging 5,000 eggs per female (Fisher 1994; Healey and Heard 1984).

Central Valley Steelhead ESU and Central Valley Steelhead Critical Habitat

The Central Valley steelhead were determined by NMFS to be an ESU, endemic to the Central Valley of California. On August 9, 1996, NMFS issued a proposed rule to list this ESU as endangered under the federal Endangered Species Act (61 FR 155). On March 19, 1998, the Central Valley steelhead ESU was listed as threatened (50 CFR Part 227), and critical habitat was subsequently designated on February 16, 2000 (50 CFR Part 226).

Critical habitat is designated to include all river reaches accessible to listed steelhead in the Sacramento and San Joaquin Rivers and their tributaries in California. Also included are river reaches and estuarine areas of the Sacramento-San Joaquin Delta, all waters from Chipps Island westward to Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and Carquinez Strait, all waters of San Pablo Bay westward of the Carquinez Bridge, and all waters of San Francisco Bay (north of the San Francisco/Oakland Bay Bridge) from San Pablo Bay to the Golden Gate Bridge. Excluded are areas of the San Joaquin River upstream of the Merced River confluence and areas above specific dams or longstanding, naturally impassable barriers.

The same factors that have negative effects on the winter-run Chinook salmon also impinge upon the Central Valley steelhead population. Anthropogenic alterations to the ecosystem have had the most impact to steelhead stocks.

Historically, steelhead spawned and reared in most of the accessible upstream reaches of Central Valley rivers, and their perennial tributaries. It is likely that steelhead were also present in the upper San Joaquin River drainage. Compared to fall-run Chinook salmon, steelhead generally migrated farther up into tributaries and headwater streams, where cool, well-oxygenated water was available year round. In the Central Valley, steelhead are now restricted to the upper Sacramento River downstream of Keswick Reservoir, the lower reaches of large tributaries downstream of impassable dams, small perennial tributaries of the Sacramento River mainstem and large tributaries, and the Sacramento-San Joaquin Delta and San Francisco Bay system. Few records are available regarding the occurrence of steelhead in the San Joaquin River system. Steelhead are currently found in the Mokelumne River, below Camanche Dam and in the Stanislaus River, below Goodwin dam. Steelhead have been reported in the Tuolumne River, below La Grange Dam.

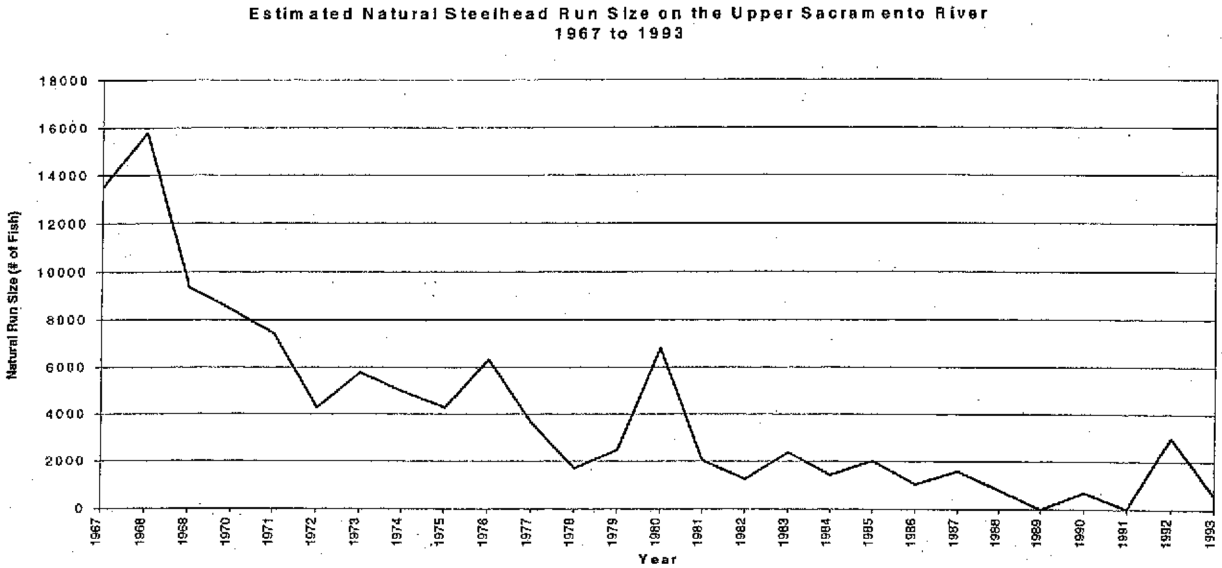
Steelhead are generally classified into two races, or runs, depending on whether they begin their upstream migration in winter or summer. Winter steelhead typically begin their spawning migration in fall and winter and spawn within a few weeks to a few months from the time they enter fresh water. Summer steelhead typically enter fresh water in spring and early summer, hold over in deep pools until they are mature, and spawn in late fall and winter. Central Valley steelhead are winter steelhead.

Historical records indicate that adult steelhead enter the mainstem Sacramento River in July, peak in abundance in the fall, and continue migrating through February or March (McEwan and Jackson 1996). Migration in the lower Mokelumne River occurs from August to March, peaking in December; spawning occurs from January through April. Unlike Pacific salmon, most steelhead do not die after spawning and a small portion survive to become repeat spawners. During spawning, the female steelhead digs a redd (i.e., gravel nest) in which she deposits her eggs, which are then fertilized by the male steelhead. Egg incubation time in the gravel is determined by water temperature and varies from approximately 19 days at an average water temperature of 60°F to approximately 80 days at an average temperature of 40°F.

Steelhead fry usually emerge from the gravel 2-8 weeks after hatching (Barnhart 1986; Reynolds *et al.* 1993); emergence usually takes place between February and May, but sometimes extends into June. Newly emerged steelhead fry move to shallow, protected areas along streambanks and move to faster, deeper areas of the river as they grow into the juvenile life stage. Juvenile steelhead feed on a variety of aquatic and terrestrial insects and other small invertebrates. Under optimal conditions, juvenile steelhead may rear in the lower Mokelumne River throughout the year (California Department of Fish and Game 1991). Small numbers of yearling and older juvenile steelhead and/or rainbow trout have been identified at Woodbridge Dam in recent years during annual monitoring of out migrating Chinook salmon (January-July). Young-of-the-year have also been observed from April through July (Natural Resource

Scientists 1998b). Similar data has been collected from the Stanislaus River during salmon monitoring efforts.

Steelhead will typically spend one to three years in freshwater before migrating downstream to



the ocean. Most Central Valley steelhead will migrate to the ocean after spending two years in freshwater, with the bulk of migrations occurring from November to May, but some low levels may occur during all months of the year. The out-migration peaks from April to May on the Stanislaus River whereas the American River has larger smolt-sized fish emigrating from December to February and smaller sized steelhead fry coming through later in the spring (March and April). Feather River steelhead smolts are observed in the river until September, which is believed to be the end of the outmigration period (CMARP 2000). In preparation for their entry into saline waters, juvenile steelhead, like winter and spring-run Chinook juveniles, also undergo a process called smoltification. During this process, fish undergo physiological and morphological changes, which allow the fish to adapt to the hypertonic environment found in the ocean. These changes involve alterations in enzyme levels, increasing activity of special salt excretion cells in the fish's gill epithelium and changes in renal activity to handle the concentrated urine production necessary to cope with the stress of osmoregulation in the ocean environment (Moyle and Cech 1982). The smolts can range in size from 14 to 21 centimeters in length (Barnhart 1986). Steelhead can spend variable amounts of time in the ocean prior to returning on their spawning migrations, ranging from one year to as many as four. Central Valley steelhead typically spend only one to two years in the ocean prior to returning to spawn in the rivers of the Central Valley. Over the past 30 years, steelhead populations have declined substantially as illustrated in Figure 2 for the upper Sacramento River natural run size.

Figure 2:
Source: McEwan and Jackson 1996

Central Valley Spring-run Chinook Salmon ESU and Critical Habitat

The Central Valley spring-run Chinook salmon were determined by NMFS to be a unique ESU, endemic to the Central Valley of California. The State of California listed the spring-run Chinook salmon as threatened species under the California State Endangered Species Act February 1999, followed by federal listing as a threatened species under the ESA (September 1999). In February 2000, NMFS designated critical habitat for the spring-run Chinook salmon as all river reaches accessible to listed Chinook salmon in the Sacramento River and its tributaries in California. Also included are river reaches and estuarine areas of the Sacramento-San Joaquin Delta, all waters from Chipps Island westward to Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and Carquinez Strait, all waters of San Pablo Bay westward of the Carquinez Bridge, and all waters of San Francisco Bay (north of the San Francisco/Oakland Bay Bridge) from San Pablo Bay to the Golden Gate Bridge (50 CFR Part 226). Many of the same factors described above that have led to the decline in the winter-run ESU are also applicable to the spring-run ESU, particularly the exclusion from historical spawning grounds found at higher elevations in the watersheds.

Chinook salmon range along the North Coast from Kotzebue Sound, Alaska to Central California (Healey 1991). Within California there are two distinct spring-run populations; the North Coast Klamath-Trinity and the Central Valley populations. Chinook salmon runs can be differentiated by timing of spawning migration, degree of maturity of fish when entering freshwater, spawning areas, and the emigrating time of the juveniles (DFG 1998).

Adult Central Valley spring-run Chinook salmon migrate between March and September, peaking in May through June, and spawn from late August through early October, peaking in September (Yoshiyama *et al.* 1998). Between 56 to 87 percent of adult spring-run Chinook salmon enter freshwater to spawn are three years of age (Calkins *et al.* 1940; Fisher 1994). Spring-run Chinook salmon in the Sacramento River exhibit an ocean-type life history, emigrating to the ocean as fry, subyearlings, and yearlings. Juvenile spring-run Chinook salmon may spend several months resting and feeding in the Delta and estuary for several months prior to entering the ocean (Kjelson *et al.* 1981).

Central Valley spring-run Chinook salmon differ from Central Valley fall-run Chinook salmon in timing of migration, adult size, fecundity, and smolt size. The spring Chinook salmon run timing enables fish to gain access to the upper reaches of river systems prior to the onset of prohibitively high water temperatures and low flows that inhibit access to these areas during the fall. Fish hold over throughout the summer in these cool upper reaches until reaching sexual maturity and subsequently spawn between August and October (Yoshiyama *et al.*1998).

Historically, spring-run Chinook salmon were abundant in the Sacramento River system and constituted the dominant run in the San Joaquin River Basin (Reynolds *et al.* 1993), occupying the upper and middle reaches (450-1,600 meters in elevation) of the San Joaquin, American, Yuba, Feather, Sacramento, McCloud and Pit Rivers. Smaller sustaining populations were found throughout most other tributaries with sufficient cold-water flow to maintain spring-run adults through the summer prior to spawning (Stone 1874; Rutter 1904; Clark 1929; Meyers 1998).

Clark (1929) estimated that there were historically 6,000 stream miles of salmonid habitat in the Sacramento-San Joaquin River Basin, but by 1928 only 510 miles remained. The elimination of access to spawning and rearing habitat resulting from the construction of impassable dams has extirpated spring-run Chinook salmon from the San Joaquin River Basin, historically supported the greatest numbers of spring-run Chinook salmon. Construction of impassible dams has also curtailed access to suitable spawning habitat in the upper Sacramento and Feather Rivers.

The remaining streams believed to sustain populations of wild spring-run Chinook salmon are Mill and Deer creeks, and possibly Butte Creek (tributaries of the Sacramento River). These remaining populations are relatively small and exhibit a sharply declining trend. Demographic and genetic risks of extirpation due to small population size are thus considered to be high. Spring-run Chinook salmon are unable to access historical spawning and rearing habitats in the Sacramento and San Joaquin River Basins are restricted to spawning in the mainstem tributaries of the Sacramento River. This limited spawning habitat, as well as corridors used for migration, are substantially marred by elevated water temperatures, agricultural and municipal diversions and returns, restricted and regulated flows, entrainment of migrating fish into unscreened or poorly screened diversions, and the poor quality and quantity of remaining habitat. Adult escapement/spawning stock estimates for the past thirty years have shown a highly variable population for the spring-run Chinook ESU. Even though the abundance of fish may increase from one year to the next, the overall average population is generally declining during this time period (see Figure 3).

Figure 3:
Source: PFMC 2000 Ocean Fisheries, Yoshiyama 1998

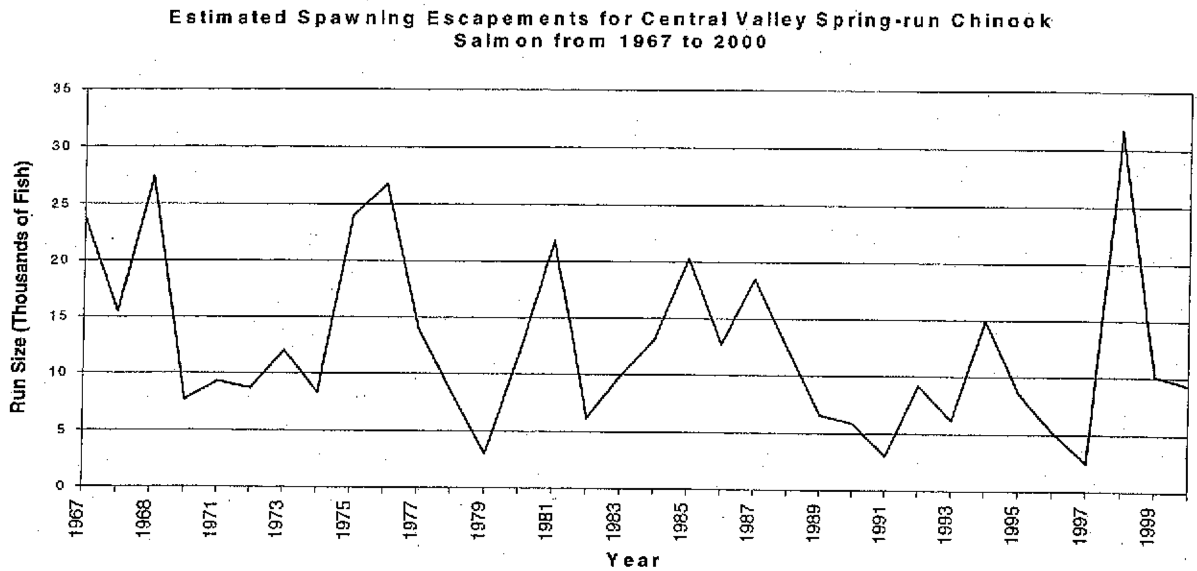
IV. ENVIRONMENTAL BASELINE

Sacramento-San Joaquin Delta

The Sacramento- San Joaquin River drainage system comprises streams and rivers draining primarily from the Sierra Nevada Range into the two major rivers of the Central Valley, the Sacramento River (fed by its major tributaries, the American, Yuba, and Feather Rivers) flowing southward and the San Joaquin River (fed by the Merced, Tuolumne, and Stanislaus Rivers) flowing northward. The Sacramento-San Joaquin drainage basins encompass about 40 percent of the state of California (approximately 153,000 square kilometers (km^2)) and carry about 600 cubic meters per second of water (mean annual flow). The two rivers join in a complex series of channels and islands called the Sacramento-San Joaquin Delta (Delta). Two main east-side tributaries flow into the Delta, the Calaveras and the Mokelumne/Cosumnes River groups. The Delta flows westward into Suisun Bay and eventually into the northern reaches of San Pablo

Bay through the Carquinez Straits (Conomos *et al.* 1985; Nichols *et al.* 1986; and Wright and Philips 1988).

The San Francisco Bay estuary, with a surface area of 1,240 km^2, is the largest coastal embayment on the west coast of the United States. Salt water tidal influence extends over 100 km landward from the bay's entrance at the Golden Gate, influencing river height as far inland



as Sacramento and Tracy in the Central Valley. The extent of salt water intrusion into the Delta (2x zone- 2 ‰ practical salinity units) extends into the eastern regions of San Pablo Bay and the Carquinez Straits during a normal winter, but extends to the eastern reaches of Suisun Bay during summer. Currently the Bay's tidal prism is approximately 24 percent of its total volume (Conomos *et al., 1985*) and is of a mixed semi-diurnal type, thus there are two unequal high tides every 25 hours, which enhances the mixing and movement of water bodies in the Delta. This relatively large tidal prism, compared to other estuaries, enables the Delta to exchange a greater amount of water volume per tidal cycle than is commonly experienced in most estuarine habitats.

The depth and shape of San Francisco Bay and the Delta have been radically altered since the mid-1800's. Conomos *et al.* (1985), Nichols *et al.* (1986), and Wright and Philips (1988), summarized these changes to the Bay-Delta system. Hydraulic mining practiced from 1854 to 1884 to uncover gold ore in the Sierra Nevada mobilized tens of millions of cubic meters of rock, soil, and debris. This inflow of debris laden runoff choked rivers and tributaries, smothering salmon spawning grounds, filling in river channels, and creating periodic extensive flooding. Downstream, in the Delta and Bay, 1.0, 0.75, and 0.25 meters of sediment was deposited in Suisun, San Pablo, and San Francisco Bays respectively as a result of the hydraulic mining era. Accelerated rates of natural sedimentation processes contributed to a permanent reduction in the open water areas of the bay through shoaling and expansion of marshlands across newly formed mudflats. This alteration in the natural landscape of the Bay and Delta altered the native biological communities, smothering benthic habitats with siltation, decreasing deep-water habitat and increasing shallow water and marsh habitat which were colonized by both native and invasive species. Conversely, reductions in the area of native marshlands also occurred in both the Delta and Bay. Nearly 1,400 km^2 of freshwater marsh in the Delta and 800 km^2 of saltwater marsh in the Bay were diked and drained to create farmland in the Delta or salt evaporation ponds in the Bay. Later, industrialization and urbanization reclaimed even more wetland acreage until today only 125 km^2 (about 6 percent) of the original 2,200 km^2 area of native wetlands remains. The original wetlands served as significant foraging areas for numerous species, enhanced nutrient cycling and retention as well as acting as natural filters to enhance ambient water quality.

Delta Water Quality

The water quality of the Delta has been negatively impacted over the last 150 years. Increased water temperatures, decreased dissolved oxygen levels, and increased turbidity and contaminant loads have degraded the quality of the aquatic habitat for the rearing and migration of salmonids. Reservoir storage is equivalent to about 80 percent of mean annual runoff in the Sacramento River basin, and about 135 percent in the San Joaquin (Kondolf 2000). Reduction of winter floods has reduced sediment transport capacity and channel dynamics to 17 percent of original transport capacity. The Central Valley Regional Water Quality Control Board in its 1998 303(d) lists the Delta as an impaired waterbody having elevated levels of chlorpyrifos, DDT, diazinon, electrical conductivity, Group A pesticides (aldrin, dieldrin, chlordane, endrin, heptachlor, heptachlor epoxide, hexachlorocyclohexane (including lindane), endosulfan and toxaphene), mercury, low dissolved oxygen, organic enrichment, and unknown toxicities (CRWQCB-CVR 1998).

Reduction in water flows, removal of riparian corridors and their shading function, and increased levels of industrial and agricultural discharges have increased ambient water temperatures in the Delta. Water temperatures typically exceed 60° to 66°F (15.5°C to 18.3°C) from April through September. Salmonids are physiologically suited to inhabit coldwater temperature regimes and increased water temperatures will lead to physiological stress in exposed salmonids. An increase in water temperature causes a concurrent decrease in the amount of oxygen that can be dissolved in the water. Reduced oxygen content in the water will result in the fish having to expend more energy to circulate a greater volume of water through its gills to extract the minimal amount of oxygen needed for survival. A fish will either increase its ventilation rate, ventilation volume or both in response to hypoxic conditions. In general, as water temperature increases, the oxygen consumption rate of the fish will also increase, indicating an increased metabolic load on the fish's body. Metabolic energy that might have been used for other physiological functions must now be used to maintain respiratory requirements, to the detriment of those other functions (Moyle and Cech 1982). Dissolved oxygen concentrations are often decreased due to the discharge of municipal, industrial and agricultural effluents that contain compounds that increase the biological oxygen demands (BOD) of the receiving waters. Salmonid physiology requires oxygen concentrations of at least

7.75 mg/L to function at optimum levels. Dissolved oxygen levels of 6.0 mg/L or less result in salmonids exhibiting signs of physiological distress (Reiser and Bjornn 1979). Increased trace metal burdens such as mercury, copper, and selenium are currently found in water quality samples from the Delta, and often are above criteria levels designed to protect the beneficial uses of water in the Delta. Increased levels of heavy metals are detrimental to the health of an organism because they interfere with metabolic functions by inhibiting key enzyme activity in metabolic pathways, decrease neurological function, degrade cardiovascular output, and act as mutagens, teratogens or carcinogens in exposed organisms (Rand 1995; Klaassen 1996). Likewise, elevated levels of pesticides and other contaminants are found in water quality samples. Pesticides typically alter the neurological functioning of an exposed organism by interfering with synaptic junction physiology within the central nervous system and neuro-muscular junctions. This interference leads to degraded locomoter activity, loss of sensory input, and disrupted equilibrium. Organisms that suffer these degradations may exhibit behavioral changes that lessen the ability to reproduce, forage, or avoid predators. In general, water degradation or contamination can either lead to acute toxicity, resulting in death when concentrations are sufficiently elevated, or more typically when concentrations are lower, to chronic or sublethal effects that reduce the fitness of the organism to survive over an extended period of time. Mortality may become a secondary effect due to compromised physiology or behavioral changes that lessen the organism's ability to carry out its normal activities. For listed species, these may be effects directly upon the listed fish or upon its prey base, which reduces the forage base available to the listed species.

Sediment Quality

Sediments can either act as a sink or as a source of contamination depending on hydrological conditions and the type of habitat the sediment occurs in. Sediment provides habitat for many aquatic organisms and is a major repository for many of the more persistent chemicals that are introduced into the surface waters. In the aquatic environment, most anthropogenic chemicals and waste materials including toxic organic and inorganic chemicals eventually accumulate in sediment (Rand 1995). Contaminated sediments can either be directly toxic to aquatic organisms or a source of contaminants for bioaccumulation in the food chain (US EPA 1994). Throughout the Delta and San Francisco Bay systems, sediments have been contaminated with industrial and urban runoff, which have carried compounds that are resistant to biological or natural chemical degradation. These contaminants are often localized around industrial and urban outfalls, storm drains, and agricultural drains. Metals such as silver, copper, cadmium, and mercury are regionally important components of the sediment contamination. Likewise selenium, a naturally occurring mineral in the marine shales of the western Central Valley, is an important contaminant in the San Joaquin River drainage due to its elevated levels in agricultural drain return waters. Selenium contamination of waters in the Central Valley has been linked to birth defects, decreased fertility and tumors in animals at the Kesterson National Wildlife Refuge and in other receiving waters in the nation (Lemley 1996, 1999). Throughout the Central Valley, elevated levels of both organo-chlorine and organo-phosphate pesticides from agricultural practices have contaminated the river basin's sediments. These compounds are frequently elevated during rain run-off events when the contaminated terrestrial soils are transported overland into the Delta waters. Pesticides are generally organ system specific, targeting the nervous system. However, reports indicate that the newer pyrethroid insecticides may have endocrine disruptor activity, as well as an extreme toxicity to fish and other gill breathing organisms (Bradbury and Coats 1989; Haya 1989). In addition, runoff from both agricultural returns and urban sources provide significant sources of nutrients to the aquatic system in the form of phosphates and nitrogen containing compounds that lead to the eutrophication of the receiving waters. Eutrophication is characterized by an increase in phytoplankton biomass (algal bloom). The increase in the biomass of phytoplankton has been implicated as one of the main sources of the low dissolved oxygen problem in the Stockton Deep Water Channel. Finally, the Delta has elevated levels of other persistent organic compounds such as polychlorinated biphenyls (PCB's), dioxins, and polycyclic aromatic hydrocarbons (PAH's), that can adsorb to sediments or organic materials, but are bioavailable to the food chain. Many of these contaminants can be bio-magnified in the food chain, leading to an eventual decrease in organismal populations through declines in reproductive success, formation of lesions in organs, or declines in metabolic status or immune response when the threshold sensitivity of the target organism is exceeded.

Herbicides enter the Delta waters from external and local inputs. One-half million pounds of over 30 different herbicides are applied annually on agricultural lands in the Delta, and an additional 5 million pounds are applied upstream in three other watersheds: the Sacramento River, San Joaquin River, and French Camp Slough (Kuivila *et al.*1999). In addition, more than 150 pesticides are applied annually in the Delta water (Kuivila 2000). Orchard spray insecticides are transported by rainfall in the winter; alfalfa pesticides and rice herbicides in the spring; and irrigation return flows transport herbicides during the summer (Kuivila 2000). In an analysis by the California Public Interest Research Group (CALPIRG) and the Pesticide Action Network (PAN) on 32 studies consisting of over 92,000 water quality samples collected by the California Department of Pesticide Regulation (DPR), it was reported that pesticides were detected at toxic levels to aquatic life more than half the time in 96 percent of all Central Valley locations tested (CALPIRG and PAN 2000). A total of 565 miles of rivers and creeks and 488,224 acres of Delta and other waterways in the Central Valley region alone have been officially recognized by the State and USEPA as being impaired by agricultural pesticides. The five most frequently detected pesticide active ingredients detected in Delta waters were diuron, diazinon, simazine, chlorpyrifos and molinate, primarily used in agriculture, weed and insect chemical controls. Other major contaminants included mercury, polychlorinated biphenyls, organochloride pesticides, and polynuclear aromatic hydrocarbons.

The Bay receives effluents from 46 publicly owned wastewater-treatment plants, 65 large industrial discharges, and as much as 40,000 tons of at least 65 contaminants each year (USGS 2001). The Bay-Delta Estuary Regional Monitoring Program indicate that the contaminants of greatest concern are: mercury, polychlorinated biphenyls (PCBs), diazinon, chlorpyrifos, and selenium. It has been demonstrated that phytoplankton uptake of the organic form of selenium may be a significant pathway for selenium to enter the food-web (Baines and Nicholas 2000; Steward et al. 2000).

Exposure to contaminated sediments may directly cause deleterious effects to listed salmonids if individual fish are directly exposed to it. This may occur if the fish swims through a plume of the resuspended sediments or rests on contaminated substrate and absorbs the toxic compounds through one of several routes: dermal contact, ingestion, or uptake across the gill epithelia. Elevated contaminate levels may be found in localized hot spots where discharge occurs or where river currents deposit sediment loads. Sediment contaminant levels can thus be significantly higher than the overlying water column concentrations (EPA 1994). However the more likely route of exposure to salmonids is through the food chain, where the fish feed on organisms that are contaminated with the toxic compounds. Prey species become contaminated either by feeding on the detritus associated with the sediments or dwelling in the sediment itself where exposure to pore waters occurs. Therefore the degree of exposure to the salmonids depends on their trophic level and the amount of contaminated forage base they consume. Salmonids exposed to increased levels of contaminants can be expected to have a decreased ability to forage or escape predators, lower fertility and reproductive abilities, increased susceptibility to disease, and an increased probability of developing lesions or tumors (Rand 1995).

Nutrient Loading

Human settlement around coastal water bodies has led to increased inputs of nutrients such as nitrogen and phosphorus. San Francisco Bay receives more than 800 million gallons of municipal wastewater containing 60 tons of nitrogen daily (USGS 2001). USGS (2001) studies show that in spite of its nutrient enrichment, San Francisco Bay has not been affected by harmful algal "blooms." This is likely due in part by abundant bottom-dwelling invertebrates (small clams, mussels, crustaceans) that filter the water and remove new algae as fast as they are produced. Bio-control of algae growth prevents tidal blooms from occurring when dissolved nutrients fuel the lowest rungs of the food chain and provide a nutrient-rich environment in which primary producers (phytoplankton, macroalgae, toxic algal species, etc.) thrive. Biofiltration benefits salmonids because it keeps their habitat from being overrun by algal blooms. However in areas where the benthic macro-fauna density is low, eutrophication of the receiving waters can cause sudden, dramatic algal blooms. The increased biomass of algae blocks light penetration into the water column, thus limiting photosynthesis to shallower waters than normally required. The balance of photosynthesis to respiration is altered in favor of respiration and more oxygen is consumed than produced by the photosynthetic process. The ambient DO levels decrease to extremely low levels, leading to "fish kills' and asphyxiation of oxygen dependent species. The decay of the dead animal and plant matter further exacerbates the already low DO levels through elevated Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) in the effected waters. Such conditions are seen in the Stockton Deep Water Ship channel and the Port of Stockton.

Sediment Loading

Fine sediment is inorganic waterborne material, usually less than 0.25 inches in diameter. It is considered the most important pollutant in streams of the western United States (Cordone and

Kelley, 1960). Suspended sediment blocks light affecting feeding and movement of fish and causes direct gill damage that could kill fish. Excessive sediment in the stream bottom may act as a physical barrier and stop the emergence of fry or prevent proper flow of water to redds. Other effects of excessive sediment include fatality, stress, altered behavior, decreased visibility affecting feeding and filling of pools which decreases living space, and reductions in growth and abundance. Adult fish can withstand high concentrations of sediment for short periods of time without harm, but sediment on stream bottoms will reduce survival of eggs and newly hatched fry (Cordone and Kelly 1960). In a lentic system, the deposition of residues of herbicides in bottom sediments would indicate that an accumulation of these residues in chironomid larvae at levels similar to those in the sediment will occur (Muir *et al.* 1982). Chironomid larvae are benthic prey organisms, facilitating biomagnification of chemicals up the food chain that could ultimately impact salmonids. There was indication that adsorption equilibrium between sediment and water, which is dependent on the organic matter content of the bottom material, is important in determining the actual residue of the herbicides in aquatic animals in the water (Muir *et al.* 1982). Prey species become contaminated either by feeding on the detritus associated with the sediments or dwelling in the sediment itself where exposure to pore waters occurs. Therefore the degree of exposure to the salmonids depends on their trophic level and the amount of contaminated forage base they consume. Salmonids exposed to increased levels of contaminants can be expected to have a decreased ability to forage or escape predators, lower fertility and reproductive abilities, increased susceptibility to disease, and an increased probability of developing lesions or tumors (Rand 1995).

Exotic Invasives

Exotic species within the Delta has disrupted the natural benthos, changed pollutant availability in the food chain, and disrupted food availability to native species. Native emergent vegetation quickly colonizes intertidal areas at intertidal elevations, but exotic submerged and floating vegetation dominates subtidal habitats like breached levee flooded islands in the Delta (Simenstad *et al.* 1999). Significantly high densities of introduced non-native sunfish and catfish species were found in these subsided habitats with submerged and floating vegetation than in open habitats or habitats with emergent vegetation, which contained significantly higher densities of larval delta smelt and juvenile *Chinook* salmon, respectively (Nobriga et al. 2000). There is also an indication that sunfish and bass (centrarchids) as well as other introduced fish species are increasing in the Delta (Kogut 2000) indicating that a substantial habitat change may be occurring in the Delta, which may encompass *Egeria* abundance. Exotics have been introduced, intentionally and otherwise, into the Delta, impacting all levels of the food web. Amphipods (e.g. *Crangonyn floridanus*), and isopods (e.g. *Caecidotea racovitzai*, *Asellus* spp.) are recent introductions to the Delta. The Asiatic clam, *Potamocorbula*, was introduced to the Bay in 1986, presumably by cargo transport, and a sequence of ecological changes followed, impacting almost every fish species living in the North Bay. Filter-feeding *Potamocorbula* has led to depletions of phytoplankton in the North Bay, followed by a drop in zooplankton abundance. Phytoplankton are a food source for small zooplankton animals that, in turn, are a critical food resource for young fish, including salmonids. The decline of salmonid populations in the action area has been due, in part, to limited prey availability caused by *Potamocorbula*.

Introduced vegetation includes the shoreline emergent vegetation (*Scirpus* sp.), riparian vegetation, and floating canopies of water hyacinth (*Eichhornia crassipes*), pennywort (*Hydrocotyle umbrelata*), and parrot's feather (*Myriophyllum aquaticum*) (Toft 1999). Likewise, extremely dense stands of exotic *Egeria* form "walls" throughout much of the subtidal Delta region and block access to intertidal habitats without submerged aquatic vegetation. Restricted access to preferred habitats may force salmonids to inhabit deep water or channel habitats where prey densities could be lower and predation risk may be higher (Grimaldo *et al.* 2000b). There is some indication that dense stands of *Egeria* support large numbers of introduced fish species and very few native species (Grimaldo *et al.* 2000a, 2000b).

Water Operations

The Sacramento River Basin provides approximately 80 percent of the water flowing into the Delta (DWR 1993). With the completion of upstream reservoir storage projects, the Sacramento River, San Joaquin River, and Delta waterways are now highly regulated systems, such that the current seasonal distribution of flows differs from historical patterns. Only 3-4 percent of the Bay-Delta's historic wetlands remain intact today. The magnitude and duration of peak flows during the winter and spring are reduced by water impoundment in upstream reservoirs. Instream flows during the summer and early fall months have increased over historic levels for deliveries of municipal and agricultural water supplies. Overall, water management now reduces natural variability by creating more uniform flows year-round. Reservoir storage capacity in the Sacramento-San Joaquin system totals 30 million acre-feet. The California State Water Project and the Federal Central Valley Project export over 5.5 million acre-feet of water annually from the Delta to central and southern California.

To a great extent, streamflow volume and runoff patterns regulate the quality and quantity of habitat available to juvenile salmonids. Salmon are highly adapted to seasonal changes in flow. Increased stream flows in the fall and winter stimulate juvenile salmonid downstream migration, improve rearing habitat, and improve smolt survival to the ocean. Over the last few years an increasing trend has been noted in the size of the winter-run Chinook salmon run. This increase has been attributed to a number of factors, including favorable environmental conditions, implementation of temperature controls on water released from storage, modified operations of the RBDD, and screening of select diversions. However, increasing trends have not been noted for other salmonid species that may be more greatly influenced by changes in natural flow in the Delta waterways from CVP/SWP pumping in the south Delta. These conditions have adversely affected Central Valley salmonids, including the spring-run Chinook salmon, through reduced survival of juvenile fish.

Juvenile salmon and steelhead migrate downstream from their upper river spawning and nursery grounds to lower river reaches and the Delta prior to entering the ocean as smolts. Historically, the tidal marshes of the Delta provided a highly productive estuarine environment for juvenile anadromous salmonids. During the course of their downstream migration, juvenile salmonids utilize the Delta's estuarine habitat for seasonal rearing, and as a migration corridor to the sea. Since the 1850's, reclamation of Delta islands for agricultural purposes has caused the cumulative loss of 94 percent of the Delta's tidal marshes (Monroe *et al.* 1992).

Once in the complex configuration of waterways in the central and southern Delta, fish are subjected to a variety of adverse conditions that decrease their chances for survival. Lower survival rates are expected due to the longer migration route, where fish are exposed to increased predation, higher water temperatures, unscreened agricultural diversions, poor water quality, reduced availability of food, and entrainment at the CVP/SWP export facilities. Through reduced Delta outflow and decreases in net westerly flow, diversion operations are expected to degrade Chinook salmon rearing habitat in the Delta, degrade conditions for natural smolt out-migration stimulus and seaward orientation, and generally reduce smolt survival. During dry and critical water years, diversions have an even greater potential for adversely affecting channel hydrodynamics and reducing winter-run Chinook salmon, spring-run Chinook salmon, and steelhead trout survival already strained by low flows, poor water quality, and high CVP/SWP entrainment rates.

In addition to the degradation and loss of estuarine habitat, downstream migrant juvenile salmon in the Delta are currently subject to adverse conditions created by water export operations at the CVP/SWP. Specifically, juvenile salmon are adversely affected by: (1) water diversion from the mainstem Sacramento River into the Central Delta via the manmade Delta Cross Channel, Georgiana Slough, and Three-mile Slough; (2) upstream or reverse flows of water in the lower San Joaquin River and southern Delta waterways; and (3) entrainment at the CVP/SWP export facilities and associated problems at Clifton Court Forebay. Salmonids are exposed to increased water temperatures from late spring through early fall in the lower Sacramento and San Joaquin River reaches and the Delta. Environmental ameliorations and fish behavior strategies off-setting increased temperatures are hampered by the loss of riparian shading and further thermal inputs from municipal, industrial, and agricultural discharges.

Diversion into the Central and South Delta

Juvenile salmon emigrating from spawning and rearing areas in the Sacramento River may be diverted into the interior Delta through the manmade Delta Cross Channel, Georgiana Slough, or Three-mile Slough. Fisheries investigations by Schaffter (1980) and Vogel *et al.* (1988) using winter-run Chinook salmon juveniles suggests that the number of salmon diverted into the central and South Delta are proportional to flow into the central Delta at the Delta Cross Channel.

Studies conducted using fall-run Chinook salmon smolts have demonstrated substantially higher mortality rates for those fish passing into the interior Delta (USFWS 1990 and USFWS 1992). The increased mortality rates reflect increased susceptibility to predation, delays in migration, exposure to increased water temperatures, and increased susceptibility to entrainment losses at the CVP/SWP export pumps and other water diversion locations within the Delta.

Reverse Flows: Channel hydrodynamics in the lower San Joaquin River and other southern Delta waterways are altered by CVP/SWP water export operations in the south Delta.

CVP/SWP pumping can change the net flow in these channels from a westward direction to an eastward direction, particularly during periods of drought and high pumping rates. When present, these 'reverse' flows move the net flow of water east up the San Joaquin River and then south towards the CVP/SWP export facilities, via Old and Middle Rivers. In general, the magnitude of reverse flow increases with the rate of export pumping. Although the mechanism is not well understood, juvenile salmon frequently pass with the net flow of water into a complex network of channels leading to the CVP/SWP water export facilities in the South Delta. Indirect losses of juvenile salmon are thought to occur in these southern Delta channels through predation, disorientation, and delayed out-migration. Direct losses to predation and entrainment are known to occur in Clifton Court Forebay and at the CVP/SWP pumping plants.

Entrainment at CVP/SWP and Clifton Court Forebay: The CVP and SWP Delta pumping plants presently have maximum capacities of 4,600 cubic feet per second (cfs) and 10,300 cfs, respectively. However, the State's existing USACE permit generally restricts the SWP's level of pumping by limiting the monthly maximum average inflow into Clifton Court Forebay to 6,680 cfs. Both projects operate fish collection facilities within the intake channels of their canals using a louver system which resembles venetian blinds and acts as a behavioral barrier. Although the slots are wide enough for fish to enter, approximately 75 percent of the Chinook salmon encountering the louvers sense the turbulence and move along the face of the louvers to enter the bypass system. The remaining 25 percent are lost to the pumping plant and canal. Additional losses occur inside the fish screening facilities from predation to striped bass and other predators. Significant handling and trucking losses also occur during the process used to transport salvaged fish to a release site in the western Delta.

RESTORATION AND ENVIRONMENTAL ENHANCEMENT PROGRAMS

CALFED

On December 15, 1994, the State of California, the Federal government, water users and environmental interests entered into a three year agreement to ensure water quality and supply and to protect the quality of San Francisco Bay and the Sacramento/San Joaquin Delta habitats with the signing of the Bay-Delta Accord. In May of 1995, the CALFED Bay Delta Program was established to carry out the goals of the accord. CALFED has a three phased implementation plan that will stretch over at least three decades. Projects will be divided into four main areas: ecosystem quality; water supply; water quality and vulnerability of Delta functions. Currently an "operations" group (CALFED Ops Group) coordinates CVP/SWP projects operations, using current biological and hydrological information for the management of water quality, endangered species, and the Central Valley Project Improvement Act. Water quality objectives and criteria established by the Accord are based on historical operations of the CVP/SWP and the life history needs of the fish species affected by Delta water operations. The combined effect of these various criteria has improved the environmental baseline of the Delta, affording a level of protection for listed species and critical habitat conservation. The goals of CALFED's Ecological Restoration Program are "to improve aquatic and terrestrial habitats and natural processes to support stable, self-sustainable populations of diverse and valuable plant and animal species, and includes recovery of species listed under State and Federal Endangered Species Acts" (CALFED, 2000a). Examples of projects conducted under the auspices of CALFED include large scale restoration projects on Clear Creek, Deer Creek, and the San Joaquin River, removal of a select group of dams, purchase of additional upstream flows, protection and restoration of the natural meander corridor to the Sacramento River, and improvement of water quality throughout the watershed.

USGS Monitoring Programs

USGS has developed a biological monitoring procedure that has been in continuous use in the Bay-Delta since 1977. In 1990, the USGS began a special series of investigations to describe the origins and effects of toxic contaminants in San Francisco Bay. Early results have shown that pesticides applied in the Central Valley of California are carried by rivers into the Bay at levels exceeding national guidelines (USGS 2001). Biological tests have shown river waters to contain high levels of pesticides soon after they are applied to fields.

Anadromous Fish Restoration Plan

USFWS' Anadromous Fish Restoration Plan (AFRP) has identified the direct and indirect impacts of the CVP and SWP Delta pumping operations as a significant factor limiting natural production of anadromous fish in the Central Valley. The AFRP (USFWS 1997) has developed numerous actions in the Delta designed to improve the outmigration and survival of juvenile salmon in the Delta (e.g. Delta Cross Channel closures, export curtailments, positive Q (discharge) west conditions.

CVPIA Section 3406(b)(1) directs the Secretary of Interior to develop and implement a program that makes all reasonable efforts to ensure by the year 2002, natural production of anadromous fish in California's Central Valley streams will be sustainable, on a long-term basis, at levels not less than twice the average levels attained during the period of 1967-1991. Fully implemented, the AFRP will meet the mitigation, protection, restoration, and enhancement purposes established by the CVPIA. The six anadromous fish species identified for restoration efforts under the AFRP are Chinook salmon, steelhead, striped bass, American shad, white sturgeon, and green sturgeon. Since 1995, the AFRP has assisted in the interim implementation of over 70 projects to restore natural production of anadromous fish, under the leadership of the Bureau of Reclamation (USBR) and the USFWS.

AFRP actions include non-flow fish management projects such as physical facilities to improve fish passage (e.g. fish screens and ladders), channel restoration to improve habitat of rearing and spawning, and replenishment of spawning gravels and fish screening to prevent the entrainment of juvenile fish and associated fish passage facilities for adults. Non-flow AFRP actions include channel and habitat restoration projects, and upstream adult fish passage facilities not associated with fish screens. In addition to improving fish passage, dam removal and modification will also benefit listed salmonids and designated critical habitat by improving downstream flow conditions, water quality (e.g. temperature), sediment transport, and other hydrological processes.

Under the auspices of the AFRP, the Anadromous Fish Screen Program (AFSP) was developed to implement measures to avoid losses of juvenile anadromous fish resulting from unscreened or inadequately screened diversions, including any of the more than 2,050 unscreened diversions in the Delta and Sacramento Valley (DFG 1998). A recent AFSP accomplishment in the Delta was the completion of the Banta-Carbona Irrigation District (BCID) Fish Screen project. A previous study reported a loss of 20,000 juvenile *Chinook* salmon during one 2-month period (Hallock and Van Woert 1959). Based on screen efficiency ratings, it is estimated that steelhead mortality/injuries during the BCID pumping season will be reduced to 4 percent of all steelhead that will be directed through the bypass system.

Striped Bass Habitat Conservation Plan

The California Department of Fish and Game has an ESA section 10 permit to annually stock San Francisco Bay with striped bass (*Morone saxatilis*), an introduced exotic species that is a popular game fish. California Department of Fish and Game (DFG) has been releasing approximately 1.275 million striped bass yearlings into San Francisco Bay as part of a five-year Striped Bass Conservation Plan developed with NMFS, and the USFWS, to prevent further striped bass declines and stabilize the striped bass population at 1994 levels of 712,000 adults. Striped bass is a predator that may be impeding the recovery of listed species including steelhead trout and Chinook salmon. The Striped Bass Conservation Plan focuses on striped bass recovery and maintenance, and is part of DFG's commitment to 1) stabilize and restore the Estuary's striped bass fishery 2) restore and improve habitat for striped bass and other aquatic species; 3) ensure that striped bass recovery programs do not jeopardize the continued existence of any state or federally listed species. The Conservation Plan also supports the Fish and Game Commission's goals to stabilize and restore the striped bass fishery in the Sacramento-San Joaquin Estuary. Planting of striped bass into the Delta has been suspended as of 2001, triggered by the attainment of the 712,000 adult population level.

National Invasive Species Management Plan

The National Invasive Species Management Plan was created by Executive Order 13112 on February 3, 1999. The Executive Order (EO) directs Federal agencies to use their authorities to prevent the introduction of invasive species, to control, monitor and to restore native species. The EO established a Federal Interagency Invasive Species Council (Council), co-chaired by the Secretaries of the Interior, Agriculture, and Commerce and includes State, Treasury, Defense, Transportation and the Environmental Protection Agency. The Council is directed to create an invasive species management plan. The Secretary of the Interior established an advisory committee to provide information and advice for consideration by the Council including recommended plans and actions at the local, state, regional and ecosystem-based levels to achieve the goals of the Management Plan. The Council acts in cooperation with states, tribes, scientific, agricultural organizations, conservation groups and other stakeholders. The Management Plan is updated every two years with an accompanying public report on success in implementation. The first edition of the Management Plan reviewed relevant existing programs and authorities, recommended needed measures, and identified legislative needs.

National Invasive Species Act of 1996

This act reauthorizes and amends the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (P.L. 101-646), which focused on preventive measures for the introduction and spread of aquatic nuisance species in marine and fresh waters of the U.S. The National Invasive Species Act of 1996 extends to the control of ballast water from ships, which has been a major contributor to introduced invasive species in domestic waters.

The Western Regional Panel on Aquatic Nuisance Species (WRP) was formed in 1997 to help limit the introduction, spread and impacts of aquatic nuisance species into the Western Region of North America. The purposes of the WRP are to: (1) identify Western Region priorities for responding to aquatic nuisance species; (2) make recommendations to the Task Force regarding an education, monitoring (including inspection), prevention, and control program to prevent the spread of the zebra mussel west of the 100th Meridian; (3) coordinate, where possible, other aquatic nuisance species program activities in the West not conducted pursuant to the Act; (4) develop an emergency response strategy for Federal, State, and local entities for stemming new invasions of aquatic nuisance species in the region; (5) provide advice to public and private individuals and entities concerning methods of preventing and controlling aquatic nuisance species infestations; and (6) submit an annual report to the Aquatic Nuisance Species Task Force describing activities within the western region related to aquatic nuisance species prevention, research and control. The Aquatic Nuisance Species Task Force (ANSTF), co-chaired by the US Fish and Wildlife Service (USFWS) and National Oceanic and Atmospheric Administration (NOAA), coordinates governmental efforts related to nonindigenous aquatic species in the United States with those of the private sector and other North American interests. CALFED is represented on the ANSTF, and it has formulated the CALFED ERP Nonnative Invasive Species Strategic and Implementation Plan (July 2000) with it's number one objective being to "develop and identify the leadership, authority and organization necessary to predict, prevent and reduce the impacts of 'nonnative invasive species' (NIS) introductions in the ecosystems of the San Francisco Bay-Delta, the Sacramento and San Joaquin Rivers, and their watersheds." A draft CALFED Rapid Response Plan, currently in review, streamlines a response process to NIS by an identified lead agency and resources. Once adopted, the response plan could be utilized to contain and eradicate identified aquatic NIS, including *Egeria*, in newly contaminated areas in California.

Total Maximum Daily Load Programs

The State Water Resources Control Board (SWRCB), in conjunction with nine semi-autonomous regional boards, regulates water quality in the state of California. The regional boards implement water quality programs in accordance with policies, plans, and standards developed by the state board. One of their responsibilities is to develop Total Maximum Daily Load (TMDL) programs, allocating responsibility for reducing non-point source pollution in the state's most seriously impaired water bodies. TMDLs are developed for each pollutant contributing to the impairment of a listed water body. Only three of the 18 impaired water bodies on the state's initial list from 1976 have been de-listed. The most recent list of impaired water bodies in the state (1998) lists 509 impaired water bodies throughout the state, for which 1,471 TMDLs have to be developed. The California Department of Water Resources Legislative Analyst's Office suggests that the SWRCB develop a 10-year development plan, through 2010-2011, for the TMDL program. Timing will coincide with EPA guidance that all TMDLs from the 1998 list of impaired water bodies be complete by 2011. The plan will include: (1) a workload summary; (2) funding requirements; (3) evaluation development; (4) a monitoring plan; (5) a schedule for achieving water quality milestones and objectives; and (6) recommendations for improvements to the plan (DWR 2001).

IEP Projects in the Delta

The Interagency Ecological Program (IEP) is a collaborative effort among nine Federal and California State agencies. The objective of the IEP is to obtain the appropriate physical and biological information necessary for protection and management of the Sacramento-San Joaquin Estuary, and its' fish inhabitants. The information gathered by the IEP program is used to access impacts on Delta fishes, and to adjust the operations of Reclamation's Central Valley Project (CVP) accordingly. In 2001, a total of 122 IEP habitat- and/or fish-related projects, based in the Delta, were funded through CALFED. Project proposals included: watershed restorations, toxicity/invasive species studies, sediment/water quality studies, geomorphoric/hydrologic studies, migration studies, prey reserves, habitat expansion, education programs, fish monitoring, and fish tag evaluations. These projects serve not only to improve environmental conditions for salmonids in the Delta, but also expand the knowledge base of the Delta's ecosystem.

Water Hyacinth Control Program

A DBW control program targeting another introduced South American plant, the water hyacinth, has been in operation from 1982 through 1999 in the Delta. It has recently been reinstated, and it is expected that a long-term permit will be issued this year by NMFS for the program's continued existence. DBW has employed herbicides as the preferred method of control for water hyacinth for 17 years. Chemicals previously utilized in DBW's control program included aquatic herbicides Weedar®64 (2,4-Dichlorophenozyacetic acid, dimethylamine salt) (2,4-D), Rodeo® (glyphosate, N-(phosphonomethyl) glycine (isopropylamine salt), Reward® (diquat dibromide); adjuvants Activator 90® (alkyl polyoxyethylene ether and free fatty acids), Placement® (amine salts of organic acids, aromatic acid, aromatic and aliphatic petroleum distillate), SR-11® (alkyl aryl polyethoxylates, compounded silicone and linear alcohol), Agri-dex® (paraffin base petroleum oil and polyoxyethylate polyol fatty acid esters), Bivert® (amine salts of organic acids, aromatic acid, aromatic and aliphatic petroleum distillates), and SurpHtac®(polyozyethylated (6) decly alcohol, 1-aminomethanamide dihydrogen tetraoxosulfate); and activator Magnify®(ammonium salts, aklyl polyglucoside, and dimethylpolysilozane). From 1983 - 1999, a total of 17,613 acres were treated with 4,861 applications of primarily 2,4-D (>95 percent total applied herbicide). For the last 6 years of the program, a total of 8,361 gallons of herbicide and 4,914 gallons of adjuvants were used in the Water Hyacinth Control Program (WHCP). An estimated 959 gallons of Weedar®64, 16 gallons of Rodeo®, and 320 gallons of Placement® were applied to Delta waters in the 2001 WHCP season, covering 1002 acres of Delta waters. The DBW estimates that it will use a maximum of 900 gallons of herbicide on 500 - 1,000 acres of Delta waterways during the 2002 treatment season.

The WHCP has four crews working 5 days per week, applying herbicides on areas that exhibit (1) the greatest concentration of water hyacinth posing a threat to navigation, and (2) serve as nurseries for new water hyacinth vegetation. Weedar®64 is the primary herbicide, applied by a handheld spray gun for topical application to the water hyacinth.

Salmonid Migration in the Delta

Chinook salmon and steelhead are present in the Delta throughout the year as juveniles migrate out to sea, or adults return to natal streams or sites of hatchery release. The start and duration of emigration is dependent upon water year type, precipitation, accretion in the Sacramento River, and water flows. Distinct emigration pulses coincide with high precipitation, increased turbidity, and storm events.

Juvenile winter-run Chinook emigrate from the Delta to the ocean from mid-December or January through June. Peak emigration of juvenile Sacramento River winter-run *Chinook* salmon through the Delta generally occurs from January through April, but the range may extend from September up to June (Schaffter 1980; Messersmith 1966; CDFG 1989, 1993; USFWS 1992, 1993, 1994). Adult Sacramento River winter-run Chinook salmon leave the ocean and migrate through the Sacramento-San Joaquin Delta to the upper Sacramento River from December through June (Van Woert 1958; Hallock *et al.* 1957).

Hallock *et al.* (1961) found that juvenile steelhead in the Sacramento Basin migrated downstream during most months of the year, but the peak period of emigration occurred in the spring, with a much smaller peak in the fall. Steelhead smolts show up at the Tracy and Banks pumping plants between December and June. Adult steelhead migrate upstream in the Sacramento River mainstem from July through March, with peaks in September and February (Bailey 1954; Hallock *et al.* 1961). The timing of upstream migration is generally correlated with higher flow events, such as freshets or sand bar breaches, and associated lower water temperatures.

Spring-run Chinook fry and fingerlings can enter the Delta as early as January and as late as June; a cohort's length of residency within the Delta is unknown but probably lessens as the season progresses into the late spring months (DFG 1998). Spring-run Chinook salmon adults are estimated to leave the ocean and enter the Sacramento River from March to July (Myers *et al.* 1998). This run timing is well adapted for gaining access to the upper reaches of river systems, 1,500 to 5,200 feet in elevation, prior to the onset of high water temperatures and low flows that would inhibit access to these areas during the fall.

Peak occurrence of juvenile salmonids varies annually. Standardized sampling during spring for a Delta monitoring program in the 1970's with a beach seine produced peak occurrence in December and March for late-fall, winter, and fall/spring runs (Burmester and Brandes 2000). Peaks shifted from November, March, and April using a Kodiak trawl, to December, March, and May with a Chipps Island midwater trawl. Peak occurrence of fall-run Chinook salmon in the lower San Joaquin River beach seine and Mossdale Kodiak trawl was in February and May, respectively (Burmester and Brandes 2000). Shifts in juvenile salmonid abundance demonstrated with various sampling gear reflect discretionary use of the Delta by juvenile salmonids based on their size, age, and degree of smoltification.

Integration and Synthesis of the Environmental Baseline

The decline of Pacific salmonids in the Delta region is not dependent upon a single factor, but rather is an interplay of several variables interacting with each other to affect the status of the species populations and the habitat necessary for their survival. Identifying any one factor does not exclude the possibility that others are also acting, perhaps synergistically, to prolong or enhance the decline, or conversely, in an antagonistic fashion to slow or perhaps even reverse the declining population trend. Furthermore, the factors affecting the current trends in the salmonid populations appear to include both natural and anthropogenic influences:

- Dam construction on the mainstem Sacramento River and the main tributaries to the Sacramento and San Joaquin rivers have significantly altered the historical seasonal flow patterns in the Delta. Salmonid populations within the Central Valley of California are evolutionarily adapted to these historical flow patterns and the water quality characteristics associated with them.

- Operation of federal and state water programs have significantly reduced the volume of water flowing to and through the Delta. Currently less than 40 percent of historical flows reach San Francisco Bay through the Delta.

- Reduction in the flow of water to the Delta has resulted in declining water quality within the Delta. The Delta is currently listed as having impaired water quality, and the SWRCB has implemented TMDLs for this waterbody. Numerous anthropogenic factors, including industrial, agricultural, and urban sources of pollutants have exacerbated the effects of low water flows to the Delta.

- Wetlands within the Delta region have been reduced to 6 percent of their historical distribution. This loss of wetlands has resulted in the elimination of crucial shallow water habitat which provided shelter and foraging opportunities for juvenile salmonids, as well as the positive effects to water quality that the natural filtering capacity of wetlands provided.

- Currently, programs such as CALFED and AFRP are instituting positive changes to water operations and habitat management that will benefit numerous aquatic and terrestrial species, including listed salmonid species. These changes should enhance the quality of the habitat in the Delta, which may facilitate populations of listed salmonids to stabilize or even increase as a result of the changes.

V. Effects of the Action

Removal of *Egeria* could result in temporary loss of cover, rearing and foraging area for juvenile salmonids. Juvenile salmonids may experience reduced oxygen levels and/or direct exposure to chemical treatments. Chemical treatments may cause a temporary decrease in abundance of invertebrate prey and removal of native submerged aquatic vegetation used by salmonids for rearing, cover and forage.

Shallow water "nursery areas" targeted for chemical treatment attract juvenile salmonids as these areas provide a rich food supply and protective cover to them. Salmon juveniles move from tidal channels during flood tide to feed in near-shore marshes. They scatter along the edges of the marshes at the highest points reached by the tide, then with receding tide, retreat into channels that dissect marsh areas and retain water at low tide. Larger juveniles and smolts tend to congregate in surface waters of main and subsidiary slough channels and move into shallow subtidal areas to feed. Although there is some preliminary research evidence that salmon and steelhead may not utilize *Egeria* (McGowan 1998), juvenile salmonids inhabiting the Delta would be vulnerable to indirect impacts from the chemical and mechanical harvesting controls, such as reduced food supply and sub-lethal toxicity effects.

The proposed period for EDCP treatment is from April to November 30. The treatment period would overlap 3 months (50 percent) of winter-run adult Chinook migration and 5.5 months (61 percent) of winter-run Chinook juvenile emigration; most of the spring-run adult migration (80 percent) and juvenile emigration (60 percent); and 8.5 months (77 percent) of adult and juvenile steelhead migration in the Delta. During out-migration, the winter-run juveniles are at sub-yearling stage (age 0); spring-run juveniles are at yearling stage (age 1) and steelhead smolts are post-yearlings (age >1).

Dissolved Oxygen Levels

Juvenile salmonids may be directly affected through the reduction in DO levels resulting from the decomposition of treated plants. Low DO levels (< 3 mg/L) can result in fish kills if fish are unable to move out of the zone of hypoxic or anoxic waters. Low dissolved oxygen levels are particularly harmful to salmonids, which have a high metabolic DO requirement (Bjornn and Reiser 1991). Studies have shown that dissolved oxygen levels below 5 mg/L have a significant negative effect on growth, food conversion efficiency, and swimming performance, compromising their survival (Piper *et al.* 1982). High water temperatures, which result in reduced oxygen solubility, can compound the stress on fish caused by marginal DO concentrations (Bjornn and Reiser 1991). Reductions in the fitness of the juvenile salmonid as a result of low DO can make the individual fish more susceptible to predation, disease, and failure to undergo smoltification due to insufficient energy reserves. Adult salmonids may experience delayed migration through Delta waters if DO is below concentrations needed for survival. Delay in upstream migration can have a negative impact on the maturation of gonadal tissue, particularly if ambient water temperatures in the Delta are also elevated. Salmonids exposed to elevated temperatures during gonadal maturation have reduced fertility and lower numbers of viable eggs (CALFED 2000c). NMFS expects that fish and mobile invertebrates will generally avoid areas with extensive infestations of *Egeria* due to the decreased ambient levels of dissolved oxygen in the water column. The applications of herbicides are expected to initially decrease dissolved oxygen levels even further in areas treated for the plant. This results from the decomposition of the dead vegetable matter and an increase in BOD. This effect is expected to be transitory as the decaying vegetation is dispersed by tidal and river currents from the treatment area. Areas of higher tidal and river current exposure will be flushed faster than areas of low water body exchange, such as dead end sloughs and restricted peripheral channels. Additional parameters affecting the DO levels are the rate of decay for the treated vegetation which is dependent on ambient water temperature and microbial activity. Higher water temperatures should theoretically result in higher microbial activity, thus resulting in a faster decline in the DO levels. However, the duration of the depressed DO levels should be shorter than in a cooler temperature profile due to the vegetative biomass being metabolized at a faster rate. Conversely, a cooler ambient temperature would result in a prolonged DO depression, although perhaps not to the hypoxic levels reached in a warmer water profile.

Narcosis

Fish, which are exposed to elevated concentrations of polar and nonpolar organic compounds, such as the herbicides used in the EDCP, can become narcotized. Narcosis is a generalized nonselective toxicity that is the result of a disruption of cell membrane function. The process of narcosis is poorly understood, but is thought to involve either a "critical volume" change in cellular membranes due to the toxicant dissolving into the lipid membrane and altering its function, or by the "protein binding" process in which hydrophobic portions of receptor proteins in the lipid membrane are bound by the toxicant molecules, thus changing the receptor protein's function (Rand 1995). Exposure to elevated concentrations of the herbicides would occur in the very upper most portions of the water column, directly beneath the fringe of the water hyacinth mat. A fish with narcosis would be susceptible to predation as a result of a loss of equilibrium, a reduction in swimming ability or a lack of predator avoidance behavior. Furthermore, a fish with narcosis would also have difficulty maintaining its position in the water column, and could potentially be carried by water currents into areas of sub-optimal water quality where conditions may be lethal to salmonids (hypoxic regions within *Egeria* mats).

Sublethal Effects on Salmonids

In contrast to the acute lethality endpoints utilized by the EDCP, nonlethal or sublethal endpoints are more appropriate to the levels of exposure likely to be seen in the herbicide application protocol employed in the program. Sublethal or nonlethal endpoints don't require that mortality be absent; rather it indicates that death is not the primary toxic endpoint being examined. Rand (1995) states that the most common sublethal endpoints in aquatic organisms are behavioral (e.g., swimming, feeding, attraction-avoidance, and predator-prey interactions), physiological (e.g., growth, reproduction, and development), biochemical (e.g., blood enzyme and ion levels), and histological changes. Some sublethal effects may indirectly result in mortality. Changes in certain behaviors, such as swimming or olfactory responses, may diminish the ability of the salmonids to find food or escape from predators and may ultimately result in death. Some sublethal effects may have little or no long-term consequences to the fish because they are rapidly reversible or diminish and cease with time. Individual fish may exhibit different responses to the same concentration of toxicant. The individual condition of the fish can significantly influence the outcome of the toxicant exposure. Fish with greater energy stores will be better able to survive a temporary decline in foraging ability, or have sufficient metabolic stores to swim to areas with better environmental conditions. Fish that are already stressed are more susceptible to the deleterious effects of contaminants, and may succumb to toxicant levels that are considered sublethal to a healthy fish.

Indirect Effects

Indirect effects may result from temporary reductions in primary productivity and invertebrate populations in treated reaches, increased water temperatures in previously shaded habitats, and exposure to predation resulting from a loss of cover as a result of exposure to the chemical compounds used in the EDCP. Invertebrate populations may be reduced either by direct toxic exposure to herbicides in the water column or indirectly by drifting decaying vegetation smothering the benthic substrate they inhabit. Either avenue would diminish the forage base needed by juvenile salmonids utilizing the Delta as a rearing habitat. Juvenile salmonids would then be forced to enlarge their forage area to successfully ingest the necessary caloric intake for survival. The rate of survival for juvenile salmonids would be a balance between the amount of metabolic energy expended in swimming during foraging behavior versus the amount of caloric intake achieved from the prey captured during foraging. Caloric intake needs to exceed the metabolic cost of swimming in order for the juvenile fish to have sufficient energy reserves for growth and other metabolic needs. An additional indirect effect is the increase in monitoring for the status of listed fish (i.e. delta smelt and splittail), where listed fish other than the target species are caught as bycatch in the sampling procedures. This bycatch often results in the loss of the listed salmonids. Finally, operation of the program's watercraft in the project area may result in direct and indirect effects due to wake turbulence, sediment resuspension, physical impact with propellers, and discharge of pollutants from the motor's exhaust and lubrication systems.

Beneficial Effects

Reductions in the percentage of *Egeria densa* infested waterways will theoretically result in better flows through these waterways, re-establishment of native aquatic vegetation, and recolonization of habitats with native invertebrate species. These changes should result in positive effects on the suitability of the Delta waterways for salmonid rearing and migration. Although these benefits are stated in the DBW Biological Assessment, definitive data was not given to support this claim and hence must be taken as potential benefits rather than actual benefits.

TOXICITY OF EDCP HERBICIDES

Fluridone

There are potential impacts to intertidal wetlands plant species if Sonar® treatment is done adjacent to such areas and water column concentrations are sustained at treatment levels for approximately six weeks. Long-term exposure could significantly alter existing local plant community composition adjacent to these treatment sites due to the rates of recolonization and species abundance for pioneering plants. Since fluridone is slow acting, decomposition of plant material will slowly decrease levels of DO. When applied at label rates, fluridone is toxic to other aquatic plants and agricultural crops it comes in contact with for an extended period of time. Fluridone photodegrades but may remain in bottom sediments for four months to one year (Muir and Grift 1982).

In a study on toxicities of fluridone to aquatic invertebrates and fish, the acute median lethal concentrations of fluridone were 4.3 ± 3.7 mg/L for invertebrates, and 10.4 ± 3.9 mg/L for fish. Invertebrates were approximately three times more sensitive than fish on an acute basis but about equally sensitive on a chronic basis. No chronic effects were appreciably detected in daphnids (*Daphnia magna*) at 0.2 mg/L concentration, amphipods (*Gammarus pseudolimnoeus*) at 0.6 mg/L, or midge larvae (*Chironomus plumosus*) at 0.6 mg/L. Channel catfish (*Ictalurus punctatus*) were not adversely affected at exposure to 0.5 mg/L fluridone; however, their tissue concentrated fluridone at two to nine times greater than that in the water column. An initial fluridone concentration of 0.1 mg/L or less is recommended to not adversely affect aquatic life (Hamelink *et al.* 1986). Uptake and clearance of fluridone by chironomid larvae were more rapid than for rainbow trout. Studies show that Sonar is hazardous to rainbow trout at 11.7 mg/L (CWQCB 2001); the Washington Department of Ecology reported a 96-hour LC_{50} level of 7.1 - 7.7 ppm for rainbow trout, in their risk assessment of Sonar® .

Assuming the worst case scenario, using the highest predicted environmental concentration (20 ppb) and the LC_{50} (lethal concentration at which 50 percent of exposed test organism die) for rainbow trout (11.7 ppm), the instantaneous concentration for fluridone in the treatment area is approximately 600 times lower than the 96 hour LC_{50} for fluridone. Furthermore, the concentration of fluridone is expected to decrease rapidly due to mixing and dilution in Delta waters after application. Fluridone will also be adsorbed to particulate matter suspended in the water and onto sediments on the bottom of the Delta waterways. Bacterial degradation will remove fluridone from the system and metabolize it to simple carbon compounds. Fluridone will also undergo photolytic decomposition. The half-life for fluridone in aquatic environments is approximately 21 days (Extoxnet 2002). The environmental fate characteristics of Sonar® and the application rates used in the EDCP would indicate that the concentration levels of the herbicide achieved in Delta waters should be significantly below the acute toxicity levels for salmonids exposured to fluridone.

However, sublethal effects are of concern. As mentioned previously, these are the category of effects that are most likely to occur during this program. Sublethal effects are characterized as those that occur at concentrations that are below those that lead directly to death. Sublethal effects produce less obvious effects on behavior, biochemical and/or physiological functions and the histology of the fish. In addition, potential narcosis in exposed fish can lead to negative effects including increased predation and death as described above. Degradation of critical habitat is expected to occur due to decreases in dissolved oxygen, decreases in the invertebrate standing population which reduces the forage base available to the juvenile salmonids and changes in water quality, particularly ambient water temperature due to a decrease in vegetated cover.

Diquat

Diquat is moderately toxic in freshwater with 96-hr LC_{50} values ranging from 10 - 30 mg/L (Lorz *et al.*1979). Label instructions for diquat specify that application rates in shallow water (<1m) should be reduced, and diquat use should be discouraged in water bodies containing sensitive fish species during their early life stages (Bauer 1994). Early fish life stages are more affected by diquat than older fish life stages; there is also indication that higher temperatures may enhance the toxicity of diquat (Paul *et al.*1994). Aquatic organisms are usually exposed to multiple lower-level exposures (Campbell *et al.* 2000). The 8-hr LC_{50} for diquat dibromide is 12.3 mg/L in rainbow trout and 28.5 mg/L in Chinook salmon. The 96-hr. LC_{50} for diquat dibromide is12 mg/L for rainbow trout and 28.5 mg/L for fingerling trout (Kamrin 1997). The use of diquat at recommended treatment levels could delay downstream migration of smolts and possibly affect their survival in seawater (Lorz *et al.* 1979). The U.S. Environmental Protection Agency water quality criteria (1973) has established a criterion of 0.5 mg/L diquat (instantaneous maximum) as the concentration that is protective of freshwater aquatic life.

Toxicity of diquat to fish varies with species, and with water hardness and pH (*Lorz et al.* 1979; Shaw and Hamer 1995). The Delta's hard water affords some protection to fish by the chelation of diquat. Hardness of the water varies from 138 mg/L $CaCO_3$ to 255 mg/L $CaCO_{3,}$ averaging between 164 mg/L $CaCO_{3,}$ and 230 mg/L $CaCO_{3.}$ However, there may be sublethal effects in fish exposed to chemical treatments, as manifested in an increase in hemoglobin (Hb) and hematocrit (Hct) concentrations 12 days after catfish (Ictalurid sp.) were exposed to malachite green (Salah El-Deen and Rogers 1992). Histological observations of the gills indicated that the lamellar epithelium thickened after chemical exposure, hindering the exchange of gases between the gill lamellae and the water. An increase in Hct of rainbow trout after exposing the fish to low pH for 3 days was attributed to an increase to erythrocyte swelling, reduction in plasma volume, and mobilization of erythrocytes from the spleen, in response to increased circulating catecholamine (stress reaction) (Salah El-Deen and Rogers 1992). Histological examination of diquat-exposed fish showed degenerative necrosis of the liver, kidneys, and gill lamellae of chronically exposed coho salmon. In acute exposures, gill tissues exhibited the most degeneration although the liver did show limited necrosis (Lorz *et al.* 1979).

Diquat dissipates rapidly in water, and chemically binds to sediment quickly (Ritter et al. 2000). However, in a study by Paul *et al.* (1994), it was found that despite the availability of sediment to remove diquat from the water column, the sediment alone only removed 60 percent of the diquat after four days in a shallow container which continued to be mixed by aeration. Several other field studies with variable results indicate the difficulty in ascertaining the time and rate of diquat dissipation (Yeo 1967; Grzenda *et al.*). However, literature indicates that diquat can remain bioavailable for several days (Paul *et al.* 1994). Diquat can enter fish through the gills, but the compound does not accumulate against the concentration gradient and small quantities are found in the flesh (Newman 1970). Paul *et al.* (1994) concluded that diquat was more toxic to early life stages of fish than fluridone and that the use of diquat provides an inadequate margin of safety. The potential for exposure from chemicals cannot be determined from toxicity data and initial concentrations alone; it is essential to consider environmental fate.

In a study of diquat effects on coho yearlings, the 96-hour LC_{50} was estimated to be 30 mg/L and 144-hour LC_{50} was 19 mg/L. When the survivors of static diquat exposure tests were placed in seawater, deaths occurred in a dose dependent manner in all groups of yearling coho exposed to concentrations greater than 1.0 mg/L. Acute exposure of yearling coho salmon salmon to diquat produced moderate mortality (30-75 mg/L); and the subsequent challenge with seawater elicited a dose-dependent response, even at concentrations that were sublethal in freshwater. No statistically significant effect of the herbicides on (Na, K)-stimulated ATPase activity of the gill was observed. Coho salmon acutely and chronically exposed to diquat exhibited migratory inhibition upon release into a small coastal stream (Lorz *et al.* 1979).

Diquat is highly toxic to some aquatic animals. *Hyalella azgeca*, an amphipod, is one of the most sensitive aquatic organisms tested with a 96-hour LC_{50} of 0.048 mg/L (Wilson and Bond 1969, as cited in Bauer 1994). There is also some data that suggest that diquat is more toxic at higher temperatures (Bauer 1994). Photodegradation plays a small part in the removal of diquat from the water column. The safety margin for the use of diquat appeared to be very small in a study on the toxicity of diquat to early life stages of fish, as the LC_{50}s were very close to the predicted concentration (Bauer 1994).

In a study on the effects of an herbicide combination of diquat plus endothall, the proposed treatment rate for each herbicide in mixture was less than if each were used separately. Even though some additive effects were noted, the margin of safety of the mixture was substantial since its toxic level was well above the proposed field treatment rate. Diquat governed the effects of the mixture because the toxicity values of diquat and the mixture were similar. Histological changes in gill tissue appeared at similar concentrations of diquat alone or in mixture (Berry 1984).

Assuming the worst case scenario, using the highest predicted environmental concentration (0.37 ppm) and the most sensitive LC_{50} (0.74 ppm), the instantaneous diquat concentration is still two times lower than the most sensitive LC_{50} values which are for larval fish. The instantaneous concentration is almost 77 times lower than the published LC_{50} values for Chinook and 31 times lower than those for rainbow trout are. The environmental fate characteristics of Reward® and the application rates used in the EDCP would indicate that the concentration levels of the herbicide achieved in Delta waters should be significantly below the acute toxicity levels of listed salmonids.

As mentioned previously, sublethal effects are of concern. These are the category of effects that are most likely to occur during this program. Sublethal effects are characterized as those that occur at concentrations that are below those that lead directly to death. Sublethal effects produce less obvious effects on behavior, biochemical and/or physiological functions and the histology of the fish. In addition, potential narcosis in exposed fish can lead to negative effects including increased predation and death as described above. Degradation of critical habitat is expected to occur due to decreases in dissolved oxygen, decreases in the invertebrate standing population which reduces the forage base available to the juvenile salmonids and changes in water quality, particularly ambient water temperature due to a decrease in vegetated cover.

Effects of Copper

Copper is a heavy metal, having a density greater than 6 grams/cm^3. It is operationally defined as a transitional metal or trace metal that is frequently elevated in concentration and is potentially toxic at that level. Copper is an essential nutrient needed for normal metabolic activity by living animals and plants, but some organisms are more sensitive to copper than others (e.g. marine vs. freshwater). Copper is problematic for animals with gills. Gill response to copper toxicity is mucus secretion. At high copper concentrations, mucus secretions precipitate and coagulate, causing respiratory failure due to collapse of the gill lamellae. Low concentrations of copper still cause the precipitate to form; however, mucus is secreted rapidly enough to allow the mucus to be cleared from the gill structure before it coagulates. The effect of added unchelated ionic copper to an aquatic system on photosynthesis and nitrogen fixation is a slight stimulation response at very low additions and a rapid toxic effect soon after. Sources of ionic copper in the environment include factory by-products, herbicides, copper pipes, and copper mines. Soluble ionic copper is toxic; over time, some copper becomes chelated, and some ends up in the sediment as copper sulfide, oxy-hydroxide copper, in organic matter, and carbonate-sorbed. Mechanisms for copper removal include: (1) immobilization by microbially-mediated transformation from soluble to insoluble forms (e.g. soluble copper sulfate to insoluble copper sulfide); (2) sorption and ion exchange with organic matter; (3) direct uptake by algae, bacteria, fungi, or higher plants; and (4) adsorption to soil.

Sublethal levels of copper inhibit the sodium (Na^+)- potassium (K^+)-stimulated ATPase activity in fish, interfering with the plasma water-electrolyte balance that promotes seawater osmoregulation during transition from parr stage to smolt stage. Lorz and McPherson (1977) reported that copper and mixtures of cadmium or zinc with copper were detrimental to smolting in coho salmon.

Hazel and Meith (1970) found that exposure to copper ion concentrations greater than 100 to 300 ppb for ten days was acutely toxic to Chinook salmon eggs. Copper toxicity is a function of dosage (concentration and exposure time). Hazel and Meith (1970) reported alevin mortalities of 12, 93, and 100 percent with ten-day exposures of 20, 40, and 80 ppb, respectively.

Copper sulfate is highly toxic to fish life even in relatively low concentrations (Simonin and Skea 1977). McKee and Wolf (1963) reported the highest concentrations of copper sulfate tolerated by different species were: trout, 0.14 mg/L; carp and suckers, 0.33 mg/L; catfish , 0.40 mg/L; black bass, 2.0 mg/L; and sunfish, 1.35 mg/L. There was no corresponding data on temperature, water quality or exposure time; however, toxicity of copper sulfate is affected by pH, hardness and alkalinity of water (Boyd 1990). Chelated copper formulations do not precipitate readily in high alkalinity waters, but stay in solution and remain active longer than copper sulfate. Chelated copper formulations are slightly less toxic to fish than copper sulfate. However, in waters with low alkalinity (< 20 ppm) or in water with an alkalinity of <50 ppm that contain trout, chelated copper use is extremely risky, particularly during the hot summer months (Murphy and Shelton 1996).

The effects of diquat plus copper ion on rainbow trout (*O. mykiss*), mayfly nymphs (*Baetis bicaudatus*), and water scavenger beetles (*Tropisternus lateralis*) differ for each life stage and species. The rate of application for algae control was 100 ppb diquat plus 150 ppb copper, applied for three hours. Concentrations of 800 ppb diquat plus 1,200 ppb copper ion did not reduce the number of viable fish eggs or the number of hatched eggs, nor harm alevins or water scavenger beetles. However, concentrations fives time the latter caused a 17 percent reduction of beetles. Alevins were killed at 4,000 ppb diquat plus 6,000 ppb copper. Trout fry and mayfly nymphs were killed when exposed to 400 ppb diquat combined with 600 ppb copper ion (Yeo and Dechoretz 1971). Aquatic insects displayed more sensitivity to the herbicide combination than did trout, and mayfly nymphs were more susceptible than immature water scavenger beetles, indicating potential impacts to fish prey species.

In a study on synergistic effects of Cutrine®, a chelated copper compound algaecide, with diquat, on brown trout (Salmo trutta), data indicated that Cutrine® was the primary cause of mortality. Trout are more susceptible to Cutrine® than are largemouth bass, and therefore, it is not recommended to apply copper sulfate in waters inhabited by trout. For rainbow trout (O. mykiss), diquat alone produced a 48-hour lethal time (TL) of 20.0 ppm, and a 96-hour TL at 11.2 ppm.

The EPA's California Toxics Rule (CTR) lists values for water hardness-dependent continuous (4-day average) and maximum (1-hour average) for dissolved copper criteria for freshwater aquatic life protection. These concentrations are 4.1 micrograms per Liter (µg/L) and 5.7 µg/L, respectively, based on an assumed water hardness of 40 mg/L of calcium carbonate ($CaCO_3$). The proposed concentration for dissolved copper from the Komeen® trials is 750 µg/L. This level of copper is significantly greater than the levels cited as protective to freshwater organisms in the CTR criteria. The acute 96 hour LC_{50} values for rainbow trout (*O. mykiss*) exposed to dissolved copper were in the range of 50 µg/L (soft water) to 150 µg/L (hard water) according to EPA data. Chronic exposure criteria are considerably lower than the acute values, having an LC_{50} value of 11.4 µg/L. The levels of dissolved copper created by the application of the Komeen® to *Egeria densa* beds will be acutely lethal to salmonids in the application area, exceeding by 5 to 15 times the listed LC_{50} values for rainbow trout.

Behavioral Response of Fish to Herbicides

Rheotropism refers to fish behavior in a current of water, either directly as a response to water flowing over the body surface or indirectly as a response to the visual, tactile or inertial stimuli resulting from the displacement of fish in space (Harden-Jones 1968; Arnold 1974, as cited in Dodson and Mayfield 1979). Fish respond physically and behaviorally to foreign stimuli (see Attachment 2). Rainbow trout yearlings exposed to 0.5 ppm and 1.5 ppm of diquat (278 g/L diquat dibromide) for 24 hours exhibited no significant variation in the frequency of positive rheotaxis, exhibiting an increase in the frequency of no response and a significant decrease in swimming speeds caused by short-term exposure to diquat (Dodson and Mayfield 1979). Subtoxic effects of diquat on yellow perch (Perca flavescens) include a level of respiratory stress indicated by the cough response and reduced swimming speeds in exposure to 1.0 to 5.0 ppm diquat over 48 hours to 72 hours (Bimber *et al.* 1976, as cited in Dodson and Mayfield 1979). Fish exposed to diquat over longer periods of time may move passively downstream and into decreasing concentrations of diquat, exhibiting a passive avoidance response. The level of chemical absorption is dependent upon the fish. Hiltebran *et al.* (1972) exposed bluegills to diquat and demonstrated that as the length of exposure time increased, proportionally less diquat appeared to have been absorbed. It was unknown if this result was due to the metabolism, or elimination, of diquat. A "leveling off" of diquat residues in fish tissue was observed in increasing diquat concentrations rather than with increasing exposure time (Dodson and Mayfield 1979).

In a study on overt avoidance reaction of rainbow trout to nine herbicides, Folmar (1976) noted that trout strongly avoided low concentrations (0.0001 - 0.01 mg/L) of copper sulfate, and surmised its' presence in the water may influence the selection of habitat by fish. Gardner and LaRoche (1973) demonstrated histopathological lesions of the olfactory lobe in fish exposed to copper, possibly enhancing the sensitivity of the avoidance response by irritating the olfactory system.

Chemical Synergy

Chemical residues could contribute to toxicity caused by unknown sources in several waterways within the EDCP project area. Over 30 different herbicides are applied annually on agricultural lands in the Delta, and an additional 5 million pounds are applied upstream in the Sacramento River, San Joaquin River, and French Camp Slough (DRP 1996, as cited in Kuivila *et al.* 1999). Chemicals used by the EDCP may build up on sediments at treatment sites. High additive concentrations of herbicides are likely to impair primary production in a localized event (Kuivila *et al.*1999). Water flow through treated locations can carry herbicides to adjacent areas while concentrations in the water are still high enough to cause adverse impacts to aquatic organisms, if present, and possibly irrigation, municipal waste supplies and recreation.

To reduce the possibility of non-directed herbicide impacts to salmonids and habitat, and identify and determine what those environmental impacts actually are, the EDCP will follow monitoring and sampling protocols as outlined within this Opinion, and as mandated within the draft NPDES Permit No. CA9984735 for DBW's *Egeria densa* control.

Potential Chemical Spills

A potential impact of the EDCP is an accidental spill of toxic chemicals in the project area which could lead to mortality of either migrating adults or juveniles salmonids holding in the river. An inadvertent release of diquat may cause drastic copepod mortalities in an aquatic ecosystem (Naqvi *et al.* 1980). The reported residual copper readings taken up to 1000 feet from the treated research plot in Sandmound Slough corroborates movement of Komeen® with the tidal flows, and possible impacts to native vegetation and fauna associations outside of the treated areas over a 24-hour time span. Copper compounds are toxic to a broad spectrum of aquatic organisms and must be used with extreme care. Elemental copper does not break down and can accumulate in sediments. Copper can have adverse effects on the behavior, physiology, and reproduction function of fish. It has also been shown to damage tissue and organs, which may result in mortality from either acute or chronic toxic effects. In addition, there is the chance that oil, grease, or petroleum-based residues spilled from the operations of DBW boats could injure or kill a salmonid within the area of the spill. In order to avoid this scenario, DBW staff will perform maintenance protocols that will minimize the chance of a potential chemical spill and adopt response plans that have been developed to contain chemical spills on land and in the water in the advent of a spill. In the event of an EDCP chemical herbicide spill, DFG, the County Agricultural Commissioners (CAC), the CRWQCB, the Office of Emergency Services, and if applicable, the California Highway Patrol, County Health Departments, and the County Sheriff's Office, will all be notified as needed.

Removal of Native Submerged and Emergent Aquatic Vegetation

Native submerged and emergent vegetation may be harmed or killed by the application of herbicides during the EDCP depending on the level of exposure. During periods of juvenile salmonid migration, treated areas may not provide the necessary vegetative cover or food resources needed by the fish. Treatment could possibly magnify this impact, increasing the areas devoid of aquatic vegetation or having compromised water quality. NMFS believes that these localized effects will reduce the probability of survival of juveniles emigrating through or rearing in the treatment area. Adjacent untreated acreage could be available to provide shelter and foraging for the juvenile salmonids as they move out of the treated area. However, expenditures of valuable metabolic reserves will have to be utilized for swimming to these new areas, making these reserves unavailable for other physiological needs like growth or smoltification. This shift in the utilization of metabolic energy stores has the potential to decrease the fitness and hence the survivability of the juvenile salmonid.

However, NMFS believes that a reduction in native vegetation would be temporary, as plants recolonize the treated area. Removal of the thick mats of *Egeria* will allow light penetration to submerged plants in areas previously shaded by these mats. Likewise, *Egeria* will not crowd out emergent plants by smothering and abrading them. Treated areas will also allow the native plants the opportunity to re-colonize these areas without competing with *Egeria* for space and resources.

Declines in the Abundance of Invertebrate Food Resources

The chemical compounds proposed for use in the EDCP should not reach toxic levels to invertebrates if they are applied at the labeled rates. Regions of low dissolved oxygen caused by drifting mats of decaying vegetation or smothering of benthic substrate may cause a localized decrease in populations and diversity of invertebrates. This would temporarily affect salmonid foraging success in treated areas until these areas are flushed with non-treated water and invertebrates re-establish themselves. Invertebrates have limited ability to migrate out of the treatment area, and thus are more susceptible to the effects of the dissolved oxygen levels. Following treatment, new populations of invertebrates will re-establish themselves through larval recolonization of the area as soon as habitat conditions are suitable for their growth. Therefore, as a result of the EDCP, portions of the critical habitat for Sacramento River winter-run and Central Valley spring-run Chinook salmon as well as Central Valley steelhead will be negatively impacted until water quality is re-established in the treated areas and the native invertebrate species can re-establish themselves in sustainable populations.

Summary of Effects

Based on the foregoing analysis, NMFS anticipates that applications of Sonar® or Reward® to the waters of the Delta and its tributaries during the 2002 treatment season, with EDCP monitoring and spill prevention protocols in place, will not result in acute lethal effects to listed salmonids. In addition, application of these herbicides is not expected to result in bioaccumulation of these compounds within the tissues of listed salmonids or any of the potential negative consequences that such a bioaccumulation would cause.

However, there is a potential loss of a certain fraction of the migrating population that is exposed to the toxicants or the degraded environmental conditions resulting from the implementation of the EDCP. Though fish should not be present in the cores of *Egeria* mats, they may be present along the periphery of the mats, utilizing it for cover from overhead predators. Thus, fish may be exposed to herbicides that are applied to the margins of the mat or to herbicides present in the water column directly below the mat or flowing out of the area of application. As stated in Rand (1995), sublethal effects in the listed salmonids can be expected to take the form of physiological, biochemical, behavioral, or histological changes in the exposed fish. These changes may not be immediately lethal, but can eventually cause the fish to develop a lesser level of fitness, thus reducing its chances of survival as compared to unexposed fish.

Furthermore, NMFS believes that the reduction in dissolved oxygen resulting from decaying *Egeria* in treated areas will have a negative effect on the fitness of exposed salmonids in those areas. Even though salmonids should be able to avoid areas of depleted oxygen, if adequate escape routes are maintained as dictated by the operational protocols for the EDCP, they may need to expend valuable metabolic energy to do so. This could result in depleted energy stores that could have been used for other physiological needs, such as growth, smoltification, foraging, or in the case of adults, gonadal maturation. In addition, fish exposed to herbicides and their adjuvants in the water column, in and adjacent to the application area, may experience narcosis. This physiological state will expose the fish to increased predation risks, due to a loss of equilibrium, swimming ability and predator avoidance behavior.

Indirect effects of the EDCP on critical habitat are demonstrated by the anticipated reduction in the invertebrate forage base for juvenile salmonids in the Delta. The reductions in the invertebrate populations are related to the projected decreases in ambient DO in the application areas, and the potential for benthic substrate to be smothered from decaying vegetation as it settles to the bottom. In addition, it is anticipated that water temperatures in shallow water habitats cleared of *Egeria* will increase due to a decrease in shade from floating vegetative cover. Temperatures in treated shallow water habitats may extend beyond the physiological comfort range for juvenile salmonids as the season progresses, a function of increased heating from solar irradiation. This situation will eventually be attenuated as native vegetation colonizes the treated areas, creating shaded habitat.

The degree to which listed salmonids may be impacted by the implementation of the EDCP is a function of their presence within the action area. The endangered Sacramento River winter-run Chinook salmon adults will have approximately a two month overlap in April and May, when the tail end of the upstream migration is occurring and the EDCP is starting its application schedule. Although winter-run adults will be primarily migrating up the Sacramento River corridor, some fish have been known to stray into the central Delta prior to their upstream migration. Juvenile winter-run Chinook salmon are known to utilize the Delta through May and into June, indicating a potential of a three month overlap with the EDCP. Threatened Central Valley spring-run Chinook salmon are anticipated to have an exposure of four months for adults (April-July) and three months for fingerlings and fry (April-June). The threatened Central Valley steelhead may have the most exposure as juveniles are migrating through the Delta year round with a peak in the spring and a lesser peak in the fall. The peak of juvenile steelhead outmigration in spring will overlap with approximately two months of the EDCP. Adult steelheads are likewise known to be migrating through the Delta year round on either their upstream spawning run, or their downstream emigration to the ocean. The peaks of migration through the Delta for spawning occurs from late fall through early spring, corresponding with increased water flows, but fish continue to pass through the Delta year round. Outmigration of adults occurs after spawning and peaks in late spring and early summer, during the EDCP application period.

In general, adult salmonids are not expected to be impacted by the EDCP, as they utilize deep water habitat which is not slated for EDCP chemical control treatments. DBW will be consulting the IEP tracking website for incidence of juvenile salmonids prior to treatment, to avoid impacting emigrating salmon and steelhead. DBW will also consult with NMFS on implementation of the EDCP based on real-time juvenile migrations; and for sites reported as free of salmonids and therefore safe to chemically treat for *Egeria*.

VI. CUMULATIVE EFFECTS

Cumulative effects are defined in 50 CFR 402.02 as "those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation." Future federal actions are not considered in this Opinion because they require separate consultation pursuant to section 7 of the ESA. On-going impacts identified in the Environmental Baseline section of this Opinion are expected to continue at current rates. Cumulative effects on the Sacaramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon and Central Valley steelhead; and Central Valley spring-run Chinook salmon and Central Valley steelhead designated critical habitat, include the impacts of point and non-point source chemical contaminant discharges. These contaminants include numerous pesticides and herbicides associated with discharges related to agricultural and urban activities. Implicated as potential sources of mortality for salmon and steelhead, these contaminants may adversely affect salmonid reproductive success and survival rates. Migration corridors and refugia areas would be affected if lost or made unavailable due to toxic substances.

Additional cumulative effects may result from any future non-Federal diversions of water that may entrain adult or juvenile fish or that may decrease outflows incrementally. Water diversions through intakes serving numerous small, private agricultural lands and duck clubs in the Delta, upstream of the Delta, and in Suisun Bay contribute to these cumulative effects. These diversions also include municipal and industrial uses, as well as providing water for power plants. State or local levee maintenance may impact critical habitat by disturbing migration corridors or rearing habitat and resuspending contaminants into the water.

The introduction and spread of exotic species may occur when levees are breached or when separate creeks or river systems are connected by channelization projects. Several exotic species may adversely affect salmon and steelhead, including the Asian clam (*Potamocorbula amurensis*) and three non-native species of euryhaline copepods. The Asian clam could potentially play an important role in affecting the phytoplankton dynamics. Exotic copepods may displace native species and reduce feeding efficiency and ingestion rates of juvenile salmonids, slowing their growth and making them more vulnerable to starvation and predation.

Increased boating activity in Delta waterways is expected to erode channel banks, increase siltation and turbidity, churn up benthic sediments, resuspend contaminated sediments, and degrade areas of submerged vegetation. This in turn reduces habitat for the invertebrate forage base required for the survival of juvenile salmonids. Increased boating operations will also result in more contamination from the operation of engines on powered craft entering the water bodies of the Delta. The Delta region, which includes portions of Contra Costa, Alameda, Sacramento, San Joaquin, Solano, Stanislaus and Yolo counties, is expected to increase in population by nearly 3 million people by the year 2020 (California Commercial, Industrial and Residential Real Estate Services Directory 2001). Increases in urbanization and housing developments can impact habitat by altering watershed characteristics, increasing both water use and stormwater runoff and introducing unregulated pesticides and herbicides as well as nutrients into the environment through domestic and industrial applications. Natural gas development and production in the Delta can alter watershed habitat for pipeline alignments and may introduce pollutants into the Delta in the event of a spill. Agricultural practices in the Delta may reduce riparian and wetland habitats through upland modifications of the watershed that lead to increased siltation or reductions in water flow in stream channels flowing into the Delta. Unscreened agricultural diversions throughout the Delta entrain all life stages of listed fish. Grazing activities from dairy and cattle operations can degrade or reduce suitable critical habitat for listed salmonids by increasing erosion and sedimentation as well as introducing nitrogen, ammonia, and other nutrients into the watershed, which then flow into the receiving waters of the Delta.

VII. Conclusion

After reviewing the current status of Sacramento River winter-run Chinook salmon, threatened Central Valley steelhead, and threatened Central Valley spring-run Chinook salmon, the environmental baseline for the action area, the effects of the proposed EDCP and the cumulative effects, it is NMFS's biological opinion that the 2002 EDCP, as proposed, is not likely to jeopardize the continued existence of the Sacramento River winter-run Chinook salmon, Central Valley steelhead, and Central Valley spring-run Chinook salmon, and is not likely to destroy or adversely modify Sacramento River winter-run Chinook salmon designated critical habitat. No critical habitat is currently designated for Central Valley steelhead and Central Valley spring-run Chinook salmon, therefore, none will be affected.

Decreased levels of dissolved oxygen, prey abundance, and increased ambient water temperatures are expected to be short-term effects of the EDCP as are the effects of narcosis and most aspects of sublethal effects. Overall, these effects are not expected to reduce fish numbers, reproduction or distribution of the listed salmonid species to a degree that would jeopardize their likelihood of survival and recovery. Furthermore, the EDCP is not expected to alter or destroy the functioning of critical habitat within the action area to such an extent as to jeopardize the status of the listed salmonid species in the Central Valley, and should ultimately result in more available rearing habitat and refugia during out-migration for listed juvenile salmonids.

VIII. Incidental Take Statement

Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct. NMFS further defines harm to include any act which actually kills or injures fish or wildlife, and emphasizes that such acts may include significant habitat modification or degradation that significantly impairs essential behavioral patterns, including breeding, spawning, rearing, migration, feeding or sheltering. Incidental take is defined as take of a listed animal species that results from, but is not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7 (b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the proposed action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The measures described below are non-discretionary, and must be undertaken by the USDA-ARS so that they become binding conditions of any grant or permit issued to the DBW, as appropriate, for the exemption in section 7(o)(2) to apply. The USDA-ARS has a continuing duty to regulate the activity covered in this Incidental Take Statement. If the USDA-ARS: (1) fails to assume and implement the terms and conditions of the Incidental Take Statement, or (2) fails to require the DBW to adhere to the terms and conditions of the Incidental Take Statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, USDA-ARS and DBW must report the progress of the action and its impact on the species to NMFS as specified in this Incidental Take Statement (50 CFR §402.14(i)(3)).

This Incidental Take Statement is applicable to the operations of the *Egeria densa* Control

Program project as described in the biological assessment, submitted on May 15, 2000.

A. Amount or Extent of Take

The NMFS anticipates that *Egeria densa* Control Program operations will result in take of listed salmonids. This will primarily be in the form of harm to salmonids by impairing essential rearing and migration behavior as a result of reductions in the quality or quantity of their habitat. In addition, NMFS anticipates that some juveniles may be killed, injured, or harassed during the chemical application, and boat operation during the treatment process.

The take of listed salmonids will be difficult to detect because finding a dead or injured salmonid is unlikely as the species occurs in habitat that makes such detection difficult. The impacts of DBW operations will result in changes to the quality and quantity of salmonid habitat. These changes in the quantity and quality of salmonid habitat are expected to correspond to injury to or reductions in survival of salmonids by interfering with essential behaviors such as rearing, feeding, migrating, and sheltering. Because the expected impacts to salmonid habitat correspond with these impaired behavior patterns, NMFS is describing the amount or extent of take anticipated from the proposed action in terms of limitations on habitat impacts. NMFS expects that physical habitat impacts will be consistent with the project description in terms of location, scope, and compliance with proposed minimization and mitigation measures, compliant with the terms and conditions of this incidental take statement, and within the expected effects of DBW operations as described in this Opinion. Adverse effects to, and incidental take of, listed salmonids are primarily expected during the spring through fall time period.

Anticipated incidental take will be exceeded if USDA-ARS and DBW operations are not in compliance with the project description or the terms and conditions of this Incidental Take Statement, or if effects of DBW operations are exceeded or different than the expected effects described in this Opinion.

For example, within the treatment site, NMFS anticipates that DBW operations will decrease the amount of oxygen and available habitat in the Sacramento/San Joaquin Delta during the chemical treatment season. This decrease in oxygen is expected to result in reduced feeding and rearing success, or reduced survival of juveniles drawn into the complex maze of waterways in the Delta.

Discharges of chemical residue are expected to decrease availability of shallow water habitat, increase shallow water temperatures and decrease DO levels. Increased temperatures and reduced DO levels are expected to result in sub-lethal physiological stress leading to reduced fitness and survival, termination of smoltification, and delays in salmonid migration. DBW operations are expected to result in DO level changes to no less than 5.0 mg/L in open fast-flowing waters. The EDCP will also operate in closed, shallow, and/or slow-gradient waters if the ambient DO level is 3.0 mg/L or less. Resultant temperatures are expected to increase by no more than 4^0F (or 2^0F, depending on ambient water temperatures) in the receiving waters.

Decreased oxygen levels and increased temperatures in treated areas are expected to reduce rearing and feeding opportunities for juvenile salmonids migrating through the area, resulting in their reduced fitness and survival.

Operation and maintenance of the DBW facilities and the ongoing monitoring program may incidentally cause "take" of salmonids, through disturbance within salmonid habitat, or possible chemical contamination of Delta waters. These actions would cause a temporary decrease of salmonid rearing and migrating habitats, ranging from 1-2 tidal cycles to several tidal cycles, dependent upon the rate of fresh-water dilution at a particular treatment site.

B. Reasonable and Prudent Measures for Sacramento River Winter-run Chinook Salmon, Central Valley Steelhead, and Central Valley Spring-run Chinook Salmon.

NMFS believes the following reasonable and prudent measures are necessary and appropriate to minimize the incidental take of winter-run Chinook salmon, spring-run Chinook salmon, or steelhead taken in the EDCP:

1. Measures shall be taken to reduce the impact of DBW boating operations on spring-run Chinook salmon, steelhead, and winter-run Chinook salmon.

2. Measures shall be taken to reduce degradation of Delta habitat during Egeria densa control and maintenance activities.

3. Measures shall be taken to reduce impacts to juvenile Chinook salmon and steelhead from chemical control treatment and/or monitoring activities.

4. Measures shall be taken to monitor DBW operations and Delta hydrologic conditions.

5. Measures shall be taken to adaptively manage DBW operations from season to season.

6. Measures shall be taken to obtain an NPDES permit regarding the Komeen® Research Trials before commencement of actual research in Delta waters.

The USDA-ARS is responsible for DBW compliance with the following non-discretionary terms and conditions that implement the reasonable and prudent measures described above:

1. Measures shall be taken to reduce the impact of DBW boating operations on spring-run Chinook salmon and steelhead, and winter-run Chinook salmon.

Terms and conditions:

a. The USDA-ARS shall take steps to prevent oils, greases, waxes, or other materials from contaminating Delta waters.

b. The USDA-ARS shall ensure that any escaping oils, greases, waxes, floating material (liquids, solids, foams, and scums) or suspended material will be immediately contained and removed from the area of contamination.

c. The USDA-ARS shall ensure that any mixing of chemicals is conducted away from any possible contamination of Delta waters OR within a closed system with no chance of spillage.

d. The USDA-ARS shall ensure that DBW annually submits a log record to NMFS Southwest Region that documents compliance with measures 1a - 1c above.

2. Measures shall be taken to reduce degradation of Delta habitat during *Egeria* control and maintenance activities.

Terms and conditions:

a. Any *Egeria* chemical treatment shall not be applied in Delta waters if the resulting DO level is expected to fall below 5.0 mg/L. Any *Egeria* chemical treatment shall not be applied in Delta waters with an ambient DO level between 3 - 5 mg/L, to minimize the risk to any salmonid presence. Any contradiction with chemical application DO limits as stated under the program's NPDES permit shall defer to the NPDES' set conditions.

b. Chemical application rates are not to exceed the maximum label rate for a given treatment site per annual growth cycle, in lieu of any changes to the NPDES permit for the EDCP.

ACTIVE INGREDIENT	MAXIMUM LABEL RATE
Fluridone	0.150 ppm
Diquat	0.37 ppm
Copper	0.75 ppm

c. Turbidity shall be measured immediately prior to treatment and post-treatment, to assess the extent of environmental turbidity impacts attributed to control operations and help refine future operation protocols.

3. **Measures shall be taken to reduce impacts to juvenile Chinook salmon and steelhead trout from chemical control treatment and/or monitoring activities.**

Terms and conditions:

a. Chemical controls for the *Egeria* control program in the Delta shall not be applied before technical guidance on real-time juvenile migration is provided by IEP Real-Time Monitoring, found on the Internet at: http://www.delta.dfg.ca.gov/ and verbal verification from NMFS, to determine the start of each treatment season, and the areas of safe chemical application. Dependent upon type of year and in-stream flows, juvenile steelhead may be present in the Delta through May, and winter-run and spring-run Chinook salmon may be present in the Delta through June. The EDCP may operate freely from July 1 through October 15; for operation of the EDCP outside of this time frame, verification must be made by the NMFS-Sacramento biologist contact person, Mr. Jeffrey Stuart.

b. The following information shall be collected on each fish "taken" during the course of control field operations, and identified as a winter-run Chinook salmon, spring-run Chinook salmon, or steelhead trout:

   1. location of capture, including near shore habitat type and water stage;
   2. date and time of capture;
   3. fork length; and
   4. fish condition, including abrasions, or other obvious injuries or scale losses

   This information shall be submitted to NMFS as a part of the weekly reports described below.

c. Any winter-run Chinook salmon, spring-run Chinook salmon, and steelhead mortalities shall be placed in labeled whirl-pak bags and promptly frozen. Labels shall include the date/location of capture and the fork length of the fish. The NMFS Sacramento Field Office shall be notified of any Chinook salmon or steelhead mortalities as soon as possible. The NMFS office phone number is 916/930-3600. A NMFS representative will make arrangements to pick up the specimen(s).

d. An annual report of the EDCP operations shall include:

   1. a description of the total number of winter-run Chinook salmon,

spring-run Chinook salmon, or steelhead taken, the manner of take, and the dates and locations of take, the condition of winter-run Chinook salmon, spring-run Chinook salmon, or steelhead trout taken, the disposition of winter-run Chinook salmon, spring-run Chinook salmon, or steelhead taken in the event of mortality, and a brief narrative of the circumstances surrounding injuries or mortalities; and this report shall be submitted Mr. Jeffrey Stuart (see 4d.)

2. reports of contract applicators permitted by DBW to conduct EDCP chemical applications, with an accounting of the herbicide types and amounts utilized, rate of applications and location of treatments

e. USDA-ARS staff must follow Federal law and use herbicide products consistent with labeling pertaining to application windows, to allow adequate time between treatments on *Egeria densa*:

1. Reward® Landscape and Aquatic Herbicide for the control of Egeria: Repeat applications should be made on 14-day intervals, as needed, to ensure control of missed plants and regrowth; treat only 1/3 to ½ of the water body area at one time. Do not make more than 4 applications to a treated area per year.

2. Sonar®A.S., Sonar®SRP, Sonar®PR : Application to drainage canals, irrigation canals and rivers: In slow-moving bodies of water, use an application pattern that will provide a uniform distribution and avoid concentration of the herbicide.

3. Komeen® : treat 1/3 to ½ of the water area in a single operation. Add only enough Komeen for the actual area being treated. Wait 10 to 14 days before treating the remaining area. Begin treatment along the shore and proceed outward in bands to allow fish to move into untreated areas. Second applications to treatment sites may be applied after 12 weeks.

f. Fish passage shall not be blocked within treatment areas. Protocols shall be followed to ensure that EDCP operations do not inhibit passage of fish in each area slated for treatment, and these will be submitted to NMFS prior to the treatment season.

g. The USDA-ARS, in coordination with DBW, will provide a copy of each Notice of Intent (NOI) to Jeffrey Stuart, NMFS Protected Resources Division, 650 Capitol Mall, Room 8-300, Sacramento, CA 95814-4706. This notification will include the sites scheduled for treatment and a contact person for those sites.

Until otherwise noted, Jeffrey Stuart will serve as the NMFS representative on the *Egeria densa* Task Force (Task Force), and provide technical guidance to the Task Force along with carrying out the duties of a Task Force member.

4. **Measures shall be taken to monitor DBW operations and Delta hydrologic conditions.**

Terms and conditions:

a. The USDA-ARS shall ensure that the DBW follows a comprehensive monitoring plan designed to collect hydrologic and project operational information. This monitoring plan shall be submitted to Mr. Jeffrey Stuart for review and approval upon its immediate completion and prior to its implementation.

b. The USDA-ARS, in coordination with DBW, shall provide monthly monitoring reports of hydrologic conditions and control chemical discharges to Jeffrey Stuart, NMFS-Sacramento. These reports shall include information on the following parameters:

   1. Pre-treatment and post-treatment measurements on chemical residue, intertidal vegetation, planktonic populations, watertype, pH, and turbidity levels.

   2. Daily receiving water temperatures and dissolved oxygen conditions and resultant changes to those conditions from DBW discharges.

   3. Pre-treatment and post-treatment conditions of habitat to assess the effects of chemical drift on downstream habitat.

   4. The amount of herbicide applied onto each treated Delta region and habitat islands, as well as the estimated acreage of treated *Egeria* into the Delta.

c. The USDA-ARS, in coordination with DBW, shall summarize the above monthly reports into an annual report of the DBW project operations, monitoring measurements and Delta hydrological conditions for the previous treatment year for submission to NMFS by January 31 of each new year following treatment.

d. All monthly and annual reports shall be submitted by mail or fax to:

Mr. Jeffrey Stuart
NMFS, Sacramento Field Office
650 Capitol Mall, Suite 8-300
Sacramento, CA 95814
Fax: (916) 930-3629

5. Measures shall be taken to adaptively manage DBW operations.

Terms and conditions:

As part of the EDCP Task Force, the NMFS representative will be active in guiding decisions on prioritizing treatment sites in regards to the real-time presence of salmonids in the Delta.

6. Measures shall be taken to obtain an NPDES permit regarding the Komeen® Research Trials before commencement of actual research in Delta waters.

Terms and conditions:

It is necessary to comply with NPDES permit requirements before discharging Komeen® into state-controlled waterways. As of July 2002, an NPDES permit has not been issued to USDA-ARS or DBW for the use of Komeen® field trials in the Delta. A copy of the NPDES permit issued by the CWQCB needs to be sent to Mr. Stuart for his review, and assent to the implementation of the Komeen® field trials.

IX. Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. These *conservation recommendations* include discretionary measures that the USDA-ARS can take to minimize or avoid adverse effects of a proposed action on a listed species or critical habitat or regarding the development of information. NMFS provides the following conservation recommendations that would reduce or avoid adverse impacts on the Sacramento River winter-run Chinook salmon, Central Valley steelhead, and the Central Valley spring-run Chinook salmon ESUs:

1. NMFS recommends the USDA encourage alternate non-chemical controls of *Egeria densa* and other non-native invasive vegetation in the Sacramento/San Joaquin Delta and its tributaries, in conjunction with a re-vegetation program with native plants in the

Delta.

2. NMFS recommends the USDA support, through research and other means, studies which evaluate juvenile salmonid rearing and migratory behavior in the Sacramento/San Joaquin Delta, including the effects of various chemical control operations and non-point source chemical and nutrient input into the Delta on juvenile survival and behavior.

3. NMFS recommends the USDA increase public awareness of potential threats to proper ecosystem function by exotic species introductions such as *Egeria.*

4. NMFS recommends the USDA study the potential for *Egeria* to invade and alter newly created or restored shallow-water habitats in the Delta.

5. NMFS recommends the USDA pro-actively introduce state legislation to take steps to curb the importation and control the marketing of *Egeria*, and prevent future exotic species introductions.

6. NMFS recommends the USDA-ARS take measures to explore partnerships with CALFED in an effort to completely eradicate *Egeria densa* from the Delta. CALFED had been mandated with eradicating invasive species in the Delta. This is further supported by Federal Executive Order 13112 , signed February 22, 1999, regarding Invasive Species, "to prevent the introduction of invasive species and provide for their control and to minimize the economic, ecological, and human health impacts that invasive species cause".

X. REINITIATION OF CONSULTATION

Reinitiation of formal consultation is required if there is discretionary Federal involvement or control over the action and if (1) the amount of extent of taking specified in any incidental take statement is exceeded; (2) new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered; (3) the action is subsequently modified in a manner that causes an effect to the listed species that was not considered in the biological opinion; or (4) a new species is listed or critical habitat is designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, formal consultation shall be reinitiated immediately.

XI. LITERATURE CITED

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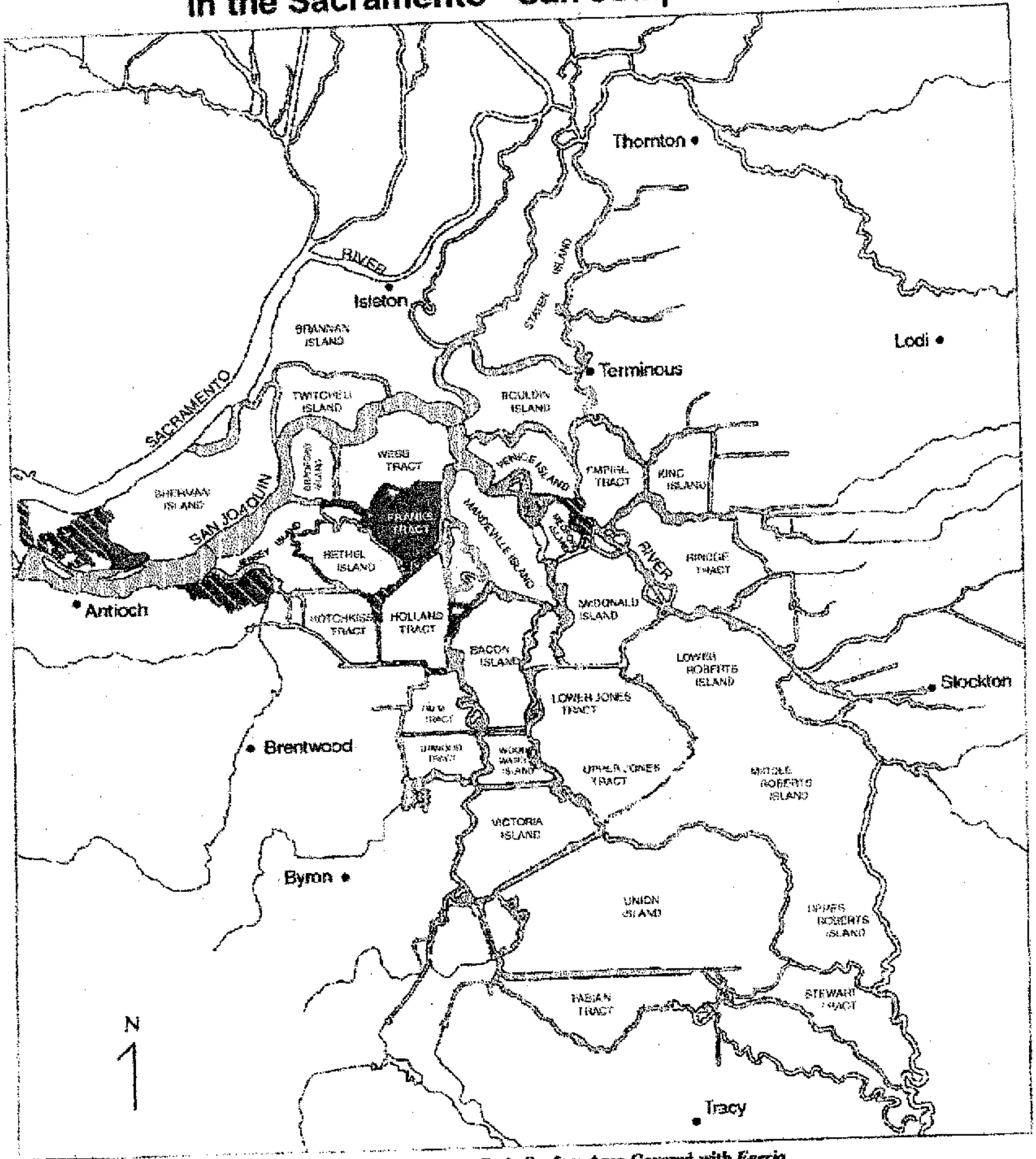
Enclosure 2.

Estimate of Relative *Egeria densa* Coverage in the Sacramento - San Joaquin Delta



Sources: CIR Aerial Photography flown 16 Sept. 1997 at 1:24,000 scale, Sacramento-San Joaquin Delta Atlas by Department of Water Resources (1993), and NewPoint Group, Inc.

Percent of Water Body Surface Area Covered with *Egeria*

0.10 < 10.0

10.0 < 20.0

20.0 < 30.0

30.0 <

0 2 4 6

Miles

Enclosure 3.

Physical Effects and Avoidance Behavior in Fish due to Chemical Contamination

"The death of some organisms, such as mysids and larval fish, is easily detected because of a change in appearance from transparent or translucent to opaque. General observations of appearance and behavior, such as erratic swimming, loss of reflex, discoloration, excessive mucus production, hyperventilation, opaque eyes, curved spine, hemorrhaging, molting, and cannibalism, should also be noted in the daily record" (Section 10.1.3, Weber, 1993).

Overt Signs of Fish Distress

- Respiratory stress - hyperventilation.
- Disorientation in swim pattern, induced by narcosis.*
- Mucus secretions from gills, mouth distension or 'cough' reflex.

Behavioral Response

- Actively move from area of contamination.
- Reduced swimming rate.
- Passively carried away from the area (some chemical impact to fish).
- Lethal concentration causes fish mortality. Fish rise to water surface, ventral-side up, with distended belly, no respiration, rigor mortis.

*Narcosis: a general, nonspecific, reversible mode of toxic action that can be produced in most living organisms by the presence of sufficient amounts of many organic chemicals. Effects result from the general disruption of cellular activity. The mechanism producing this effect is unknown, with the main theories being binding to proteins in cell membranes and 'swelling' of the lipid portion of cell membranes resulting from the presence of organic chemicals. Hydrophobicity dominated the expression of toxicity in narcotic chemicals (Rand 1995).

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Enclosure 4.

Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA)

ESSENTIAL FISH HABITAT CONSERVATION RECOMMENDATIONS[1]

The U.S. Department of Agriculture, Agricultural Research Service (USDA-ARS), in cooperation with the State of California Department of Boating and Waterways (DBW), must provide a detailed response in writing describing the measures proposed by State of California Boating and Waterways for avoiding, mitigating, or offsetting the impacts of the project on EFH.

I. IDENTIFICATION OF ESSENTIAL FISH HABITAT

The geographic extent of freshwater essential fish habitat (EFH) for the Pacific salmon fishery is proposed as waters currently or historically accessible to salmon within specific U.S. Geological Survey hydrologic units (Pacific Fisheries Management Council 1999). For the Delta, the aquatic areas identified as EFH for chinook salmon are within the hydrologic unit map numbered 1805001, 18020109, 18040002, 18040003, and 18040004. The upstream extent of Pacific salmon EFH in the Delta is to the Sacramento River and adjoining tributaries in hydrologic unit 18020109.

EFH is defined as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. For the purpose of interpreting the definition of essential fish habitat, "waters" includes aquatic areas and their associated physical , chemical, and biological properties that are used by fish, and may include areas historically used by fish where appropriate; "substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities; "necessary" means habitat required to support a sustainable fishery and a healthy ecosystem; and "spawning, breeding, feeding, or growth to maturity" covers a species' full life cycle. For the Sacramento-San Joaquin Delta, the aquatic areas that may be identified as EFH for salmon are within the hydrologic unit map numbered 18040003 (titled San Joaquin Delta).

Historically, the Sacramento-San Joaquin Delta, has served as a migratory route for immigrating adult winter, spring, and fall-run chinook salmon (*Oncorhynchus tshawytscha*) to their spawning habitat, and for rearing and emigration of juveniles returning to the ocean (Yoshiyama et al. 1996). Within the Central Valley of California, populations of winter and spring-run chinook salmon have declined significantly as a result of habitat degradation due to dams, water diversions, and placer mining, as well as past and present land-use practices. The fall-run has been reduced, however to a lesser extent than the winter-run and spring-runs (Myers 1998). Recent estimates find that fall-run chinook have declined between 85 percent to 90 percent (Rich and Loudermilk 1991; USFWS 1995) of the population levels

[1]The 1996 amendments to the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) set forth new mandates for the National Marine Fisheries Service (NMFS) and federal action agencies to protect important marine and anadromous fish habitat. Federal action agencies which fund, permit, or carry out activities that may adversely impact EFH are required to consult with NMFS regarding potential adverse effects of their actions on EFH, and respond in writing to NMFS "EFH Conservation Recommendations."

which existed in the 1940's. Fall-run chinook spawning population estimates from the Stanislaus, Tuolumne and Merced Rivers from 1974 to 1991 show both rising and descending trends lasting for several years (Kano 1996, 1998). Factors limiting salmon populations include low instream flows, high water temperature, reversed flows in the Delta (drawing juveniles into large diversion pumps), loss of fish into unscreened agricultural diversion, predation (especially by warm-water fish species), and lack of rearing habitat (Kondolf et al., 1996a, 1996b). In addition to direct losses caused by the entrainment or entrapment of fish at diversions, withdrawals of water affect both the total volume of water available to salmon and their prey, as well as the seasonal distribution of flows. Consequently, migration may be altered, changes to sediment and large woody debris transport and storage, altered flow and temperature regimes, pollution, and water level fluctuations may result (Dettman et al. 1987; CACSST 1988).

LIFE HISTORY AND HABITAT REQUIREMENTS

General life history information for fall-run chinook salmon is summarized below. Information on winter-run chinook salmon and spring-run chinook salmon is summarized in the associated Biological Opinion for the project (Enclosure 1). Further detailed information on chinook salmon ESUs are available in the NMFS status review of chinook salmon from Washington, Idaho, Oregon, and California (Myers et al. 1998), and the NMFS proposed rule for listing several ESUs of chinook salmon (NMFS 1998).

Central Valley fall-run chinook enter the Sacramento and San Joaquin Rivers from July through April and spawn from October through December (USFWS 1998) with spawning occurring from October through December. Peak spawning occurs in October and November (Reynolds et al. 1993). Chinook salmon spawning generally occurs in swift, relatively shallow riffles or along the edges of fast runs at depths greater than 6 inches, usually 1-3 feet to 10-15 feet. Preferred spawning substrate is clean loose gravel, Gravels are unsuitable for spawning when cemented with clay or fines, or when sediments settle out onto redds reducing intergravel percolation (NMFS 1997).

Egg incubation occurs from October through March, and juvenile rearing and smolt emigration occurs from January through June (Reynolds et al. 1993). Shortly after emergence from their gravel nests, most fry disperse downstream towards the Delta and estuary (Kjelson et al. 1982). The remainder of fry hide in the gravel or station in calm, shallow waters with bank cover such as tree roots, logs, and submerged or overhead vegetation. These juveniles feed and grow from January through mid-May, and emigrate to the Delta and estuary from mid-March through mid-June (Lister and Genoe 1970). As they grow, the juveniles associate with coarser substrates along the stream margin or farther from shore (Healey 1991). Along the emigration route, submerged and overhead cover in the form of rocks, submerged aquatic vegetation, logs, riparian vegetation, and undercut banks provide food, shade and protect juveniles and smolts from predation. These smolts generally spend a very short time in the Delta and estuary before entry into the ocean.

In contrast, the majority of fry carried downstream soon after emergence are believed to reside in the Delta and estuary for several months before entering the ocean (Healey 1980, 1982; Kjelson et al. 1982). Principal foods of chinook while rearing in freshwater and estuarine environments are larval and adult insects and zooplankton such as *Daphnia,* flys, gnats, mosquitoes or copepods (Kjelson et al. 1982), stonefly nymphs or beetle larvae (Chapman and Quistdorff 1938) as well as other estuarine and freshwater invertebrates. Whether entering the Delta or estuary as fry or juvenile, fall-run chinook depend on passage through the Sacramento-San Joaquin Delta for access to the ocean.

II. PROPOSED ACTION.

The proposed action is described in Part II of the associated Biological Opinion for the endangered Sacramento River winter-run chinook salmon ESU, threatened Central Valley spring-run chinook salmon ESU and their its critical habitat, as well as critical habitat.

III. EFFECTS OF THE PROJECT ACTION

The Sacramento-San Joaquin Delta is of vital importance to adult and juvenile chinook salmon as a major corridor for migration. In addition, the majority of the chinook salmon rely on the Delta and estuary for rearing that will prepare them for entry and survival in the ocean. As such, it functions as a portion of the habitat necessary to support a sustainable population. The presence and operation of DBW's Egeria Densa Control Program can interrupt the EFH habitat functions by reducing the quantity and quality of rearing, feeding, migration and sheltering habitat.

Juvenile salmon often enter the Delta before they are physiologically able to enter salt water, and rear there several months before migrating to the ocean. The proposed March through November implementation of *Egeria* control measures would occur during the upstream migration of adult chinook salmon, and during the emigration of juvenile chinook salmon.

It is anticipated that DBW operations will adversely impact the zooplankton prey base immediately after chemical application. These impacts may result in reduced feeding and rearing success, and impede juvenile migration. Water quality may be affected by increasing temperatures and chemical pollutants, and decreasing dissolved oxygen levels. These actions are expected to reduce rearing and feeding opportunities for juvenile fall-run chinook salmon by removing or otherwise destroying rearing habitat and may increase pollution input from boats. Lastly, the monitoring of listed fish species may result in the incidental capture of fall-run chinook salmon.

The *Egeria densa* Control Program will result in control of *Egeria* in the Delta, preventing further extension of its' range into salmonid rearing habitat and migration corridors for chinook salmon.

IV. CONCLUSION

Upon review of the effects of the DBW's *Egeria densa* Control Program, NMFS believes that the operation of the *Egeria densa* Control Program may impose an adverse affect on the potential EFH of fall-run chinook in the project area of the Sacramento-San Joaquin Delta.

V. EFH CONSERVATION RECOMMENDATIONS

NMFS recommends that Reasonable and Prudent Measures Numbers 1, 2, 3, and 4, and their respective Terms and Conditions listed in the Incidental Take Statement prepared for the Sacramento River winter-run chinook salmon, Central Valley spring-run chinook salmon and Central Valley steelhead ESUs in the preceding Biological Opinion be adopted as EFH Conservation Recommendations. Additional EFH Conservation Recommendations are provided below. These recommendations are provided as advisory measures.

1. The USDA-ARS, DBW and their agents should report annually to NMFS on the amount of herbicide applied onto each treated region of the Delta and habitat islands, as well as the estimated acreage of treated *Egeria* in the Delta.

2. The USDA-ARS and DBW should monitor the treated areas and implement adequate control measures to minimize areas of decreased oxygen into the Delta during *Egeria* chemical control operations.

3. The USDA-ARS and DBW should report annually on the progress and success of the restoration of the treated acres of shallow water habitat, and its benefits to fall-run chinook salmon.

VI. STATUTORY REQUIREMENTS

The Magnuson-Stevens Act and Federal regulations (50 CFR § 600.920) to implement the EFH provisions of the MSFCMA require federal action agencies to provide a written response to EFH Conservation Recommendations within 30 days of its receipt. A preliminary response is acceptable if final action cannot be completed within 30 days. Your final response must include a description of measures proposed to avoid, mitigate, or offset the adverse impacts of the activity. If your response is inconsistent with our EFH Conservation Recommendations, the USDA-ARS must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the proposed action and the measures needed to avoid, minimize, mitigate, or offset such effects.

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